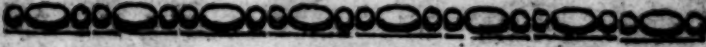


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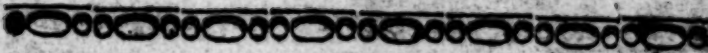
L. Blanchard

April 9th 1844



AN
E S S A Y
ON

B R E W I N G.



BRITISH MUSEUM

AN

ESSAY



BREWING.

BRITISH MUSEUM

Combrune (M.)

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A N

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O N

B R E W I N G.

W I T H

A View of establishing the Principles
of the A R T.



L O N D O N :

Printed for R. and J. DODSLEY, in *Pall-Mall*.
MDCCLVIII.

AN
ESSAY
ON
BREWING



A View of establishing the Principles
of the Art.

LONDON:
Printed by J. DODD, in Pall-mall.
MDCCLXXII.

TO THE
Master, Wardens, and Mem-
bers of the Worshipful Com-
pany of BREWERS in *London*.

GENTLEMEN,

A Long and continued attention to every event, that happened in the course of many years brewing, and an inquiry into the reasons thereof, is the foundation of this Theory of the Art, if so it may properly be called.

A sincere desire to serve the community, by establishing the Art of Brewing on invariable principles, instead of uncertain practice, was my motive for writing the following

DEDICATION.

heets. I would not, however, have presumed to lay them before the public, and put them under your patronage, had they not received the approbation contained in the following letter ; which does me so much honour, and will do the Public so much service, by engaging their attention to what comes recommended by so great a name. I am,

GENTLEMEN,

Your most obedient, and

most humble Servant,

Hampstead,
1758.

M. COMBRUNE.

[I have the Doctor's Leave for publishing the following Letter, which he was so obliging as to write to me, after perusing this little Essay.]

DEAR SIR,

I Have, with pleasure and improvement, read over your Manuscript; and should be glad to see some other Trades as justly reduced to Rule, as you have done that of Brewing: which would not only be making a right application of philosophical knowledge; but, at the same time, accommodate human life, in many respects, wherein it is still deficient. Perhaps your example may excite some other able men, to give us their respective trades, in the form of so many Arts. For my own part, having long wished to see some attempts of this kind, for the

*good of Society in general, I cannot
but be particularly pleased with the
nature, design, and execution of your
Essay; and am,*

DEAR SIR,

Your obliged Friend,

and humble Servant,

**Pall-Mall, July
20. 1758.**

PETER SHAW.



INTRODUCTION.



AN inquiry into the antiquity of the art of Brewing would certainly be a curious, but, I fear, a very useless research. In all probability, the inhabitants of the northern countries, soon after they settled there, found out a method of obtaining a liquor from Grain, similar to Wine; and, indeed, the mention of Beers, or Barley Wines, by some historians, who

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who treat of the colder parts of the *Globe*, where the Grape will not ripen, seems to put this matter beyond doubt. However, we have no reason to believe, that they arrived at any great degree of perfection in their art; for tho' the Brewers company, at *London*, were incorporated in the year 1427; and a company of the same nature in *France*, many years before, yet it is certain there was no good Beer, either in *France*, or even in *England*, till much later.

The business of Brewing formerly was, and now generally is, in the hands of men unacquainted with Chemistry, and ignorant that their art has any relation to that science, tho' it is, in reality, a considerable branch of it: consequently, from the want of a due knowledge of the elements and
in-

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instruments necessary in Brewing, and from never once imagining, that there were certain fixed and invariable principles, on which they ought to proceed, the advances made in this art could not but be slow.

In the reign of Queen *Elizabeth*, Malt began to be better made, and Hops to be used ; by the addition of these, the liquor was capable of being longer kept, and thereby had the advantage of being meliorated by time. The superiority of these two vegetables, over all others, for the purposes of Brewing, being soon known and ascertained, the legislative power prohibited the use of any thing else in the composition of beer : a law certainly of the greatest utility, by which all sophistication was prevented, and our beers rendered the best

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best in *Europe*. But, at the same time, a great difference, in point of excellency, subsisted in the same, and in different places; and this was chiefly owing to a want of principles, and rules to direct them, according to the variation of Malt in dryness, or of the seasons of the year in heat. The same fault still subsists, though the present practitioners of the art cannot plead the same excuse; for the Thermometer, by which they ought to govern themselves, is now brought to perfection; but at that time was only known to the learned, and not sufficiently improved for vulgar use.

The designs of all Brewers are,
1. To extract all the fermentable parts of the Malt, in the best manner possible. 2. To add Hops,
in

INTRODUCTION. xiii

in such proportions, as experience teaches them will preserve and meliorate the beer. And, 3. such a proportion of Yeast, as to obtain a perfect fermentation.

The generality of Brewers will be ready to alledge, that these three particulars are already sufficiently understood; and that it would be a much more useful work, to publish a remedy for those imperfections, or diseases, such as cloudiness, &c. that beer is naturally, or accidentally, subject to. But if the three designs, above laid down, be executed according to the known rules of Chemistry, such a remedy will not be wanted; for beer brewed upon clear and evident chemical principles, is neither naturally or accidentally subject to cloudiness, &c. nor to any disorder whatever.

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ever. Premiums have formerly been advertis'd for discovering a remedy for cloudiness in beer : I suspect no remedy can be found adequate to the disease ; but am certain, from experience, that if beer is brew'd according to the rules laid down in this Essay, such disorders will be prevented.

Hence it is evident, that some knowledge in Chemistry is absolutely necessary to complete the Brewer. It is a great misfortune, that Men, in general, are strongly prejudiced against having recourse to books, for instruction in their respective trades ; and that this prepossession is often of such weight as to discourage those who attempt the shaking it off, and proceeding upon just principles, tho' success is, and must be the happy effect of the one ; as failure commonly,

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monly, though falsely, reckoned unavoidable, is that of the other.

From true principles may be derived such a method of Brewing, in winter, that the beer shall be fit for use, at any limited period of time; and in summer with more success than generally is done. A better knowledge of fermentation, and the art of regulating it, will easily teach this. I do not mean to insinuate that Brewing can be better carried on in summer than in winter; but only, that if necessity requires, it may be carried on to a sufficient degree of perfection, much longer in the season, than is usual.

Before we proceed, it may be necessary to explain some few technical terms, and the properties of Fire, Air, Water, &c. as far as they relate
to

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to Brewing. I have not scrupled to make use of all the assistance I possibly could, from authors who have treated of these subjects; and whenever I dissent from them, it was because, to my apprehension, Nature evidently did so too. The reader will observe, that this Essay is design'd for men unacquainted with Chemistry: and that I do not pretend to treat of these subjects thoroughly, but only to say as much as is necessary for a Brewer to know.

The Utility of the subject is too manifest to need any thing to be said on that head: I will only observe, that the Brewers, within the Bills of Mortality, consume yearly more than six hundred thousand quarters of Malt, and nearly forty thousand weight of Hops.

A N

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AN
E S S A Y
ON
B R E W I N G.

*An Explanation of the technical
Terms in this ESSAY.*



S this Essay is designed,
as was hinted before,
for the service of men,
who, in general, are
unacquainted with che-
mistry and technical terms ; it has
been thought adviseable to avoid all
B terms

terms of art, as far as the nature of the work would admit of it, and to prefix an explanation of those that necessarily occur.

ACIDS. By acids are meant all those things which taste sour, as vinegar, lemons, spirit of nitre, spirit of salt, &c. An acid enters, more or less, into the composition of all vegetables, and is produced by, or rather is the last effect of fermentation. Mixed in a due proportion with an alkali, it constitutes a neutral salt, that is, a salt wherein neither the acid nor the alkali prevail. Acids are frequently termed acid salts, tho' generally they appear under a fluid form. Due regard ought to be had to the universal acid supposed constantly to circulate in the atmosphere.

ALKALI,

ALKALI, or alkaline salts, are salts of a nature directly contrary to acids, and always manifesting themselves by fermenting therewith : they have an urinous taste, are produced from the ashes of burnt vegetables, and by several other means.

AIR, is a thin, elastic fluid, surrounding the globe of the earth, imperceptible to all our senses, except that of feeling : it is absolutely necessary to the preservation both of animal and vegetable life.

ALCOHOL, is the pure spirit of wine, without the least particle of water or phlegm.

ANIMALS, are organized living bodies, endued with sensation. Minerals are said to grow and increase,

4 *An Essay on Brewing.*

Plants to grow and live, but animals only have sensation. Animal substances cannot ferment.

ATMOSPHERE, is that vast collection of air, with which the earth is surrounded to a considerable height.

ATTRACTION, an indefinite term, applicable to all actions whereby bodies tend towards one another, whether by virtue of their weight, magnetism, electricity, impulse, or any other latent power. It is not therefore the cause determining the bodies to approach, that is expressed by the word attraction, but the effect itself. The space through which this power extends, is called the sphere of attraction.

BREW-

BREWING, is the operation of preparing beers and ales from malt.

BOILING, may thus be accounted for. The minute particles of fuel, being by fire detach'd from each other, and becoming themselves fire, pass through the pores of the vessel, and mix with the fluid ; these being perpetually in an active state, communicate their motion to the quiescent water : hence arises, at first, a small intestine motion in the water ; and from a continued action in the first cause, the effect is increased, and the motion of the water continually accelerated ; so that, by degrees, it becomes sensibly agitated ; but the particles of fire acting on the particles that compose the lowest surface of the water, give them an im-

pulse upwards, by rendering them specifically lighter, so as to determine them to ascend according to the laws of equilibrium ; hence there is a constant flux of water from the bottom to the top of the vessel, and reciprocally from the top to the bottom ; from whence we learn the reason, why the water is hot at top sooner, than at the bottom. But as an equal heat cannot be distributed thro' the whole, the thermometer can be of no service here ; on which account it is better for brewers to heat a certain quantity just to the act of boiling, and temper it, by adding a sufficient quantity of cold water. Boiling water is incapable of receiving any increase of heat, tho' acted on by ever so great a fire, and rises, according
ing

ing to *Farenheit's* Scale, to 212 degrees.

CLOUDY BEER, is a term made use of by brewers, to express such beers, as, from the violent heat of the water they have been brewed with, are loaded with more oils than could be absorb'd by the water; from whence a muddy and grey oil is seen floating on the surface of the beer, though the body of the liquor is often transparent. This is frequently in great quantity, and exceeds the power of any known mēstruum.

COHESION, the action by which the particles of the same body adhere together, as if they were but one.

B 4

COLD,

COLD, its greatest degree is not known ; it is a relative term in opposition to Heat ; the colder a body is, the less is the agitation of its internal parts.

COLOUR, is that quality in any body, which causes that sensation we perceive when we look on a colour'd object. A greater or less degree of heat, causes different colours in most bodies ; and from a due observation of the colour of malt, we may determine with what degree of heat it has been acted upon.

CYLINDER, a solid body, supposed to be generated by the rotation of a parallelogram. A gardener's roller is a cylinder.

EARTH,

EARTH, is a fossil, and terrestrial matter, whereof our globe partly consists.

EBULLITION, is the boiling or bubbling of water, or any other liquor, when the fire has forced a free passage through it. Brewers suppose water to be just beginning to boil, when they perceive a portion of the water forced from the bottom in a right line, so as to disturb the surface: when the liquor is in this state, they call it, *through*, or upon the point of Ebullition.

DENSITY. By density is meant, the closeness, compactness, or near approach of the parts of a body to one another: the more a body weighs in proportion to its bulk, the greater
is

is its density. Gold is said to be the densest body in nature, because no body, of the same bulk, weighs so much.

EFFERVESCENCE, is a sudden agitation, arising in certain bodies upon mixing them together; which agitation generates heat.

EXTRACT. If the principal parts of a body are separated from the rest (or the more useless) by cold or hot water, these parts, collected together, are called an *Extract*.

EXPANSION, is the swelling or increase of the bulk of bodies, from heat, or any other cause.

FERMENTATION, is a sensible internal motion of the particles of a compound

compound fluid: by the continuance of this motion, the particles are gradually remov'd from their former situation, and, after some visible separation, join'd together again in a different order or arrangement, so as to constitute a new liquor. No liquors are capable of inebriating, except those that have been fermented.

FIRE, according to *Boerhaave*, is something unknown, which has the property of penetrating and dilating all solid and fluid bodies.

FREEZING POINT, is the degree of cold at which water begins to be form'd into ice, which, according to *Fahrenheit's* scale, is 32 degrees.

FROST, is when the air is in so cold a state as to convert the watery particles,

particles, that float in it, into ice : to what degree this may be continued, or how much cold may be increased, is unknown ; an artificial cold has been excited as far as 72 degrees below 0, that is, 104 degrees below the freezing point.

HEAT, one of the secondary qualities of bodies, produced by fire, and oppos'd to Cold.

ISINGLASS, a preparation from a fish call'd Huso, somewhat bigger than the Sturgeon ; a solution of which, in stale beer, is us'd to fine or precipitate other beers : it is imported from *Russia* by the *Dutch*, and from them to us.

LIGHT, consists of particles of matter inconceivably small, capable of
exciting

exciting in us the sensation of colours, by being reflected from every point of the surface of luminous bodies ; but, notwithstanding they are so exceeding small, Sir *Isaac Newton* found means to divide a single ray into seven distinct parts, *viz.* red, orange, yellow, green, blue, indigo, and violet.

MALT, in general, is any sort of grain, first germinated, and then dried : that generally us'd is made of barley, which experience has found to be the fittest for this purpose, as being the medium between the richest and the weakest grain.

MUSTS, are the unfermented juices of grapes, or any other vegetable substances.

MEN-

MENSTRUUM: any body, as water, which, in a fluid or subtilised state, is capable of interposing its parts between the small parts of other bodies, is called a menstruum, or that which has the power dissolving or extracting. Salts, in some cases, are very useful to strengthen the menstrooms, but not in the process of brewing, the power of hot water being more than sufficient to extract the fermentable parts, and these are the only useful ones.

OIL, is an unctuous, inflammable substance, drawn from several animal and vegetable substances.

PRECIPITATION. Isinglass dissolved in beer, renders it a glutinous and heavy body; this put into the beer
in-

intended to be fined, carries down, by its weight, all those swimming particles which prevent its transparency; and this act is call'd fining, or precipitation.

SALTS, are substances which readily dissolve in water, are sharp and pungent to the taste, and greatly dispos'd to unite with earth, so as to appear in a solid form, as common salt, alum, and other salts do. Acid salts taste sharp as vinegar, lemon juice, &c. Alkaline salts are urinous: and Neutral salts, being compos'd of both, are properly neither acid nor alkaline.

SUGAR, or SACCHARINE SALTS, are said to be acids smooth'd over with oil; which composition yields a sweet taste:

taste. All vegetable sweets are capable of fermenting spontaneously when crude; when boil'd, they require an addition of yeast to make them ferment. Malt, or its extracts, have all the properties of saccharine salts.

SULPHUR. Though by sulphur is commonly understood a mineral substance, yet, in chemistry, it is frequently us'd to express the oils of vegetables.

SOAP and SAPONACEOUS JUICES. Common soap is made of oil mix'd with alkaline salts: this mixture causes a froth on being agitated in water. The oils of vegetables are, in some degree, mix'd with their salts; and though the salts of vegetables are

un-

undoubtedly acid, and not alkaline, while the vegetable is in being, yet *Boerhaave* calls their juices saponaceous. No juices are suppos'd to be capable of vegetable fermentation, but such as are saponaceous.

THERMOMETER, is an instrument for measuring the increase and decrease of heat and cold; but it is of such use in the brewery, as to merit a farther explanation in an article by itself.

VEGETABLE, a term applied to plants, consider'd as capable of growth, having vessels and parts for this purpose, but generally supposed to have no sensation.

VINEGAR, is an acid penetrating
C liquor,

liquor, prepar'd from wine, beer, cyder, or a Must which has been fermented as far as it was capable; vinegar being the produce of the last stage of fermentation.

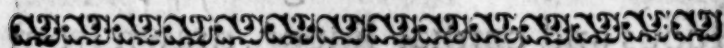
VITRIOL, in general, is an acid found in the body of the earth, mix'd either with iron, copper, or zinc. 'Tis not this concrete, but the oil, or spirit of vitriol, that is us'd in the brewery, in order to precipitate or fine brown beers that are stubborn or nearly cloudy. A pound is sometimes put into a butt; though four ounces should never be exceeded in that quantity.

WATER, is a very fluid, scentless, tasteless, colourless, transparent liquor.

WINE,

WINE, a brisk, agreeable, spirituous and cordial liquor, drawn from vegetable bodies, and fermented. In this sense beers and ales may be called, and really are, barley wines.

WORT. Worts, or Musts, may be said to be synonymous terms; the first usually applied to the unfermented extracts of Malt, as the other is to the expressed juices of vegetables.



SECTION I.

Of FIRE.

THough Fire is the chief cause and principle of almost every change in bodies ; and though the untaught in chemistry imagine, that they thoroughly understand its nature, yet certain it is, that there is nothing more incomprehensible, or that eludes our nicest research so much. The senses are very inadequate judges of it ; the eye may be deceived, and suppose no Fire in a bar of iron, because it does not appear red, though, at the same time, it may contain enough to generate pain : the touch is no positive proof,
for

for a body colder than ourselves, though, perhaps, containing numberless particles of heat, will feel cold.

The great and fundamental difference among philosophers, in respect to the nature of Fire, is, whether it be originally such, formed by the Creator himself at the beginning of things; or whether it be mechanically producible in bodies by inducing some alteration in the particles thereof. It is certain, that heat may be generated in any body by attrition; but whether it existed there before, or was caused immediately by the motion, is a matter of no great import in this Essay; for the effects, with which alone we are concerned, are still the same.

Fire expands all bodies, both solid and fluid. If an iron rod, just capable of passing thro' a ring of the same metal, is heated red-hot, it will be increased in length, and so much swelled as not to be able to pass thro' the ring, as before: if a fluid is put into a bellied glass, with a long slender neck, and properly marked, the fluid, by being heated, will manifestly rise to a considerable height.

The expansion of fluids, by heat, is different, in different fluids; and may, in general, be said to be in proportion to their density. Pure rain water, gradually heated, is expanded $\frac{1}{4}$ of its bulk, so that 85 gallons of boiling water will, when cold, measure no more than 84; and 85 gallons of boiling wort will not yield so much,

much, because the expansion is greater than that of water, in proportion as the wort is a denser liquor than water : hence we see the reason why a copper, containing a given number of barrels of boiling wort, will not produce the same number of barrels of beer when cold.

Bodies are weakened or loosened in their texture by fire : that the action of fire promotes the dissolution of bodies, is evident, for even the hardest, by an increased degree of it, will liquify and run ; and Vegetables are resolved and separated by it into their constituent parts when dried. It must be owned, Vegetables, become rigid or stiff ; but this is not owing to the fire, considered as lodged in the solid parts,

but to its evaporating the aqueous ones ; in which sense alone Fire can be said to strengthen some bodies that were before weak.

That the texture of bodies should be loosened by Fire, is a necessary consequence of expansion ; for a body cannot be expanded but by its particles receding farther from one another ; and if the particles be not able to regain the situation they had when cold, the body will remain looser in its texture, than before it suffered the action of Fire : and this is the case of barley when malted.

Fire may be conveyed through most bodies, as air, water, ashes, sand, &c. The effect seems to be different, according to the different
con-

conveyances. A difference appears between boiling and roasting, yet they answer the same purpose, that of preserving the subject; and this, in proportion to the degree of heat it hath suffered. Malts, the more they are dried, the longer are they capable of maintaining themselves in a sound state, and the liquor brewed with them will, in proportion to such dryness, keep the longer sound. Water applied to Malt to make an extract, provided it does not exceed a certain degree of heat, the hotter it is, the more durable and sounder will the extract be.

The last consideration of fire or heat that relates to brewing is, the knowledge of its different degrees,
and

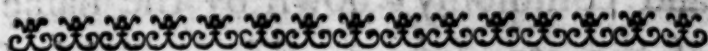
and how to regulate them : till of late, chemists, and all others, were much to seek in this respect ; they distinguished more or less Fire in a very vague and indeterminate manner ; as the first, second, third, and fourth degree of heat, meaning no precise heat, or heat measured by any standard ; but by the invention of the Thermometer, we are enabled to regulate our Fires with the utmost precision. Thermometers are formed on different scales ; and therefore when any degree of heat is mentioned, in order to avoid confusion, the scale made use of should be mentioned. I have constantly used *Fahrenheit's*, as it is the most perfect, and the most generally received. According to this instrument, 32 degrees

degrees is the freezing point, or where water first begins to harden into ice; from 32 degrees to 60, may be said to be different degrees of vegetation, according to the different plants that receive such heats; the 40th degree is marked by *Boerhaave*, as the first fermentable heat, and the 80th as the last; 47 degrees I have found to be the medium heat of *London* throughout the Year in the shade; 98 degrees is said to be that of our bodies when in health, as from 105 to 112 are its degrees when in a fever; at 175 degrees the purest and highest-rectified spirits of wine boil, and at this degree I have found well grown Malt to charr; at 212 degrees water boils; at 600 degrees, quicksilver and oil of vitriol. Iron,
Gold,

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Gold, Silver, and all other Metals in fusion exceed this heat ; greater still than any of these is the heat in the focus of the burning lens or concaves made by Vilette, and Tschirnhausen's ; these are said to volatilize metal, and vitrify bricks. Thus far experiments have reached ; but how much more, or how much less, the power of this element is, will probably be for ever unknown.

SECTION



SECTION II.

Of AIR.

NONE of the operations, either of Nature or Art, can be carried on without the action or assistance of Air. It is the principal agent in fermentation; consequently its properties and powers, some of them at least, ought to be well understood by brewers.

By Air we mean a fluid, scarcely perceivable by our senses, and discovering itself only by the resistance it makes to bodies. We find it every where incumbent on the surface of the globe, extending to a considerable, but determinate height,
and

and commonly known by the name of the atmosphere. The weight of air is to that of water as 1 to 850, and its gravitating force equal to the pressure of a column of water 33 feet high; so that an area of one foot square receives from air a pressure equal to 2080 pounds weight.

Elasticity is a property appertaining to only one of the four elements, namely, Air, and is in proportion to the compressing weight. We scarcely find this element (any more than the others) in a pure state: one thousandth part of common Air, says *Boerhaave*, consists of aqueous, spirituous, oily, saline, and other particles scattered through it, which are not compressible, and are, in general, preventive of fermentation, consequently

quently where the Air is purest, fermentation is best carried on. He likewise tells us, " It is clear, that " the ultimate particles of Air co- " here together, so as not easily to " insinuate themselves into the small- " est pores either of solids or fluids ;" from whence those acquainted with brewing easily account why hot water, which forces strong and pinguious extracts from Malt, prevents fermentation, as oils are an obstruction to the free entrance of the Air ; and from an analogous reason, why, in weak extracts fermentation is so much accelerated that the whole soon becomes sour.

Air (like other subjects) is expanded or rarefied, and acquires a greater degree of elasticity, in proportion

portion to its heat ; consequently the hotter the season, the more active and violent will fermentation be.

Air abounds with water, and is perpetually penetrating and insinuating itself into every thing capable of receiving it. Its weight, or gravitating force, must necessarily produce numberless effects ; the water contained in Air is rendered more active by its motion ; the salts and saponaceous subjects it meets with are loosened in their texture, and, in some degree, dissolved by it : as these are the principal constituent parts in Malt, the reason is obvious why those that are old, or have lain a proper time exposed to the influence of the Air, dissolve more readily,

dily, or, in other words, yield a more copious extract, than others.

By means of this penetrating and active power in the Air, all bodies in a passive state, exposed thereto a sufficient time, become of the same degree of heat with the Air itself. On this account the water lying in the backs used by brewers, may be said to be nearly of the same degree of heat as the Thermometer shews the open Air in the shade to be, except when this instrument indicates a cold below the freezing point, or 32 degrees: for if the water was then as cold as the Air, it would become ice: in this circumstance it may more properly be accounted as hot as 33 degrees; for water will not immediately become as cold as the

D Air,

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Air, on many accounts, such as its not having been long enough exposed thereto, its being pumped out of deep wells, &c.

Air is not easily expelled from bodies, either solid or fluid: water requires two hours boiling to be discharged of the greatest part of its Air. That Air may thus be discharged by heat, appears from this, that water thus boiled, instead of having any Air-bubbles when it freezes, as ice commonly has, will become a solid mass like crystal.

As Air is rendered more active by being joined to Water, that Water which has endured the Fire the least time, provided it be hot enough, will make the strongest extract.

Worts,

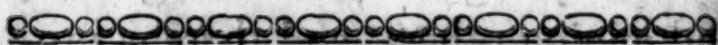
Worts, or Musts, as they contain great quantities of salts and oils, are denser bodies than common water, and therefore require a greater degree of heat to make them boil; consequently more Air is expelled by boiling worts, in a given time, than by boiling water in the same time; and as Air does not instantaneously re-enter those bodies, tho' cold, they would never ferment of themselves; and were it not for the substitute of yeast, to supply the deficiency of the Air lost by boiling, they would fox or putrify for want of an internal elastic Air, which is absolutely necessary to fermentation.

Air is more easily dislodged from hot than from cold water, because the weight of the atmosphere is less

on the former than the latter : but though there is Air in every fluid, it differs in quantity in different fluids ; so that no rule can be laid down for the quantity of Air worts should contain : probably the quantity sufficient to saturate one sort, will not be an adequate proportion for another.

Lastly, Air encompasses, is in contact with, confines, and compresses all bodies ; insinuates itself into their penetrable passages, and exerts all its power as well on solids, as on fluids ; and finding in bodies some elements to which it has a tendency, unites with them. By its weight and perpetual motion it strongly agitates the parts of bodies in which it is contained, rubs, and intermixes them
in-

intimately together, disuniting some, and joining others, and thereby producing very singular effects, not easily accomplished by any other means. That this element has such surprising powers, is evident from the following experiment. “ Fermentable parts, duly prepared and disposed in the vacuum of Mr. Boyle’s Air-pump, will not ferment, though acted upon by a proper heat ; but, discharging their Air, remain unchanged.



SECTION III.

Of WATER.

AS Water is perpetually an object of our senses, and made use of for most of the purposes of life, many people imagine, that they perfectly understand its nature: but they who have inquired into it with the greatest care, find it very difficult to form a right notion of it, because it is no easy matter to separate Water from other bodies, or other bodies from Water. Hartshorn, by being long dried, resists a file more than iron; yet, on distillation, yields much Water. I have already observed, that Air is intimately mixed with

with it; how is it possible then ever to obtain Water perfectly pure?

In its most perfect state, we understand it to be a liquor very fluid, inodorous, insipid, pellucid, and colourless, which, in a certain degree of cold, freezes into a brittle, hard, glassy ice: this furnishes us with another reason, why it is absolutely impossible to have water intirely free from every thing else, because, while it subsists in a fluid state, it contains a considerable degree of heat or fire.

Though lightness is reckoned a perfection in water, yet its certain weight is with great difficulty determined: fountain, river, or well waters, by their admixture with saline,

saponaceous, and vitriolic substances, are rendered much heavier than in their natural state; and different degrees of heat, by varying the expansion, must affect the weight of water. A pint of rain-water, supposed to be the purest, is said to weigh 15 ounces, 1 drachm, and 50 grains; but the weight is different in different seasons of the year.

A second property of Water, which it has in common with other liquors, is its fluidity; and this is so great, that a very small degree of heat above the freezing point, makes it evaporate. Few brewers, I believe, know how great a proportion of the quantity of water they use in brewing, is lost by evaporation. The
purer

purser the water, the more readily it evaporates ; so that sea-water, which is supposed to contain one fortieth part of salt, wastes much less than purser water, and more forcibly resists the effects of Fire. Notwithstanding which, as Fire ultimately divides most bodies, and has the property of separating the dense parts from the rare, a strong and continual ebullition may be a means of separating, in some measure, the impurities of the Water from the Must.

The ultimate particles of Water, *Boerhaave* believed to be much less than those of Air, as water passes thro' the invisible pores and interstices of wood, which never transmit the least elastic air : nor is there, says he, any known fluid, (Fire excepted, which pene-

penetrates every thing) whose parts are more penetrating than those of water ; but as water is not an universal dissolver, there are vessels which will contain it, though they will not contain even the thick syrup of sugar, for sugar makes its way by dissolving the tenacious and oily substance of wood ; which water cannot.

Water, when fully saturated with Fire, is said to boil, and is then under a strong ebullition ; in that state it occupies $\frac{1}{3}$ degrees more space than when cold : so that a brewer who would be exact, when he intends to reduce his liquor to a certain degree of heat, must allow for this expansion, abating therefrom the quantity of steam exhaled.

As

As Water, by boiling, may be said to be filled or saturated with Fire, so may it with any subject capable of being dissolved therein. Tho' Water will dissolve only a given quantity of any body soluble in it; yet, at the same time, it will dissolve a certain proportion of some other body: for four ounces of pure rain-water will dissolve but one ounce of common salt; though after taking this as the utmost of its quantity, it will still receive and dissolve two scruples of another kind of salt, *viz.* pulverized Nitre. In the same manner the strongest extract of Malt, or Water saturated with the soluble parts of Malt, is still capable of receiving something from Hops; but in a limited proportion, as is evident from the

the thin bitter pellicle that often swims on the surface of the first wort of brown strong beer, which is commonly over-charged with Hops, by putting the whole quantity into it: the Water not being capable of suspending all that the heat dissolves, it rises at top. This may serve for a hint, to use fewer, or rather to divide them otherwise than is generally practised.

Boerhaave believed the ultimate particles of Water to be solid spheres, rigid, perfectly inflexible, and of an adamantine hardness: whether this doctrine be true, or not, it is certain, that Water acts very differently, as a menstruum, according to its different degrees of heat: consequently its heat is a point of the utmost importance with

with regard to brewing, and must be properly varied according to the driness and nature of the Malt; to its being applied either in the first or last mashes; and in proportion also to the time the beer is intended to be kept. To this end we must have recourse to the Thermometer, as the only instrument capable of numerically determining the power of Heat or Fire.

Nutrition cannot be carried on without Water, though Water itself is not the matter of nourishment, but only the vehicle.

Water is as necessary to fermentation as heat or air: the farmer who stacks his hay or corn before it is thoroughly dried, soon experiences the

the terrible effects of too much moisture or water residing therein: all vegetables therefore intended to be kept long, ought to be well dried. The brewer should carefully avoid purchasing Hops that are slack bagged, or kept in a moist place; or Malt that has been sprinkled with water soon after it was taken from the kiln; for, by means of the moisture, a fermentation begins, which, for want of a sufficient quantity of Air, is soon stopped; but the heat thereby generated, remaining, every seed begins to grow, and forms a moss that dies, and leaves a putrid musty taste behind, which always prevails, more or less, in the beer.

Water, by some, has been accounted an universal solvent: but,
certain

certain it is, it does not act as such on all metals, gems, stones, and many other substances: it does not, in general, dissolve oils, but is miscible with highly-rectified spirits of wine, or alcohol, which is the purest vegetable oil in nature; all saponaceous bodies, whether artificial or natural, fixed or volatile, readily melt therein: the soluble parts of Malt, being oils and salts, are properly soaps, and consequently dissoluble in this menstruum; and in such manner, that neither the oil nor salt appears separately, but the whole seems to compose an homogeneous uniform mixture. One particular property of saponaceous substances, well worth our observing is, that, by being intimately mixed with oily substances, resins, &c. they render them miscible

ble with water ; consequently Hops, which contain a large portion of resin, will yield their extracts more efficaciously by being boiled in wort than in water alone : so that all pretended improvements for making extracts of Hops by themselves in water alone, or keeping a Rob of them against dear times, are absurd and ridiculous. Water not only dissolves true soaps, but, by their assistance, acquires a power of dissolving bodies which otherwise it could not. A farther proof of this (which every attentive brewer will find) is, that a given quantity of Hops, boiled in a wort by hotter water more strongly extracted, will yield a bitterer liquor, than the same quantity boiled in a weaker wort, or in water alone.

When

When a saponaceous substance is dissolved in water, it lathers, froths, and bears a head ; hence, in extracts of Malt, we find these signs in the underback ; but weak and slack liquors (the salts of the Malt only being dissolved without a sufficient quantity of the oils) not being saponaceous, yield no froth, and generally let part of the grist fall undissolved in a whitish flour : somewhat like this happens when the water for the extract is over-heated, for then, as more oils are extracted than are sufficient to balance the salts, the extract is not saponaceous ; in this case the extract comes down with little or no froth or head, as before ; but without depositing any flour in the underback : hence, tho' the head or froth of the extracts in the under-

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back

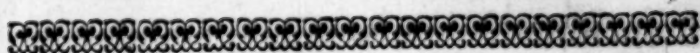
back are esteemed, by many, as sure signs and guides for regulating the progress of brewing, we see how uncertain such signs are, as direct opposites exhibit the same appearances; and should the heat of the water be increased beyond this last-mentioned degree, so as to impede the action of the Air necessary to extract with, (an error by the brewers termed *setting the goods*) instead of having a good extract, the whole runs into inseparable clods or lumps, from whence the grist is seldom or never recovered; consequently, whoever would act with certainty in this art, must rely on the Thermometer alone.

This might be a proper place to observe the difference between rain, spring, river, and pond waters; but

as the art of brewing is very little, or not at all affected by the difference of waters, if they be equally soft, but rather depends on the due regulation of heat; and as soft waters are alike, and found in most places where brewing is necessary; from hence it is evident, that any sort of beer or ale whatever may be brewed with equal success, where Malt and Hops can be procured proper for the respective purposes. And if hitherto prejudice or interest has appropriated to some places a reputation for particular sorts of drinks, has arose from hence: The art being totally defective of principles, the event depended on experience only; and lucky combinations were most frequent where the greatest practice was; and for want of

knowing the true reason the different properties observed in the several drinks were attributed to the water; but just and true principles, followed by as just a practice, renders the art universal. This truth would appear in a stronger light, were I to extend the observations farther on this element; but as the subject of Water is fully treated of by *Boerhaave*, *Shaw*, and *Hales*, it would be tedious to add any thing more upon it.

SECTION



SECTION IV.

Of EARTH.

BOERHAAVE defines Earth to be a simple, hard, friable, fossil body, fixed in the fire, but not melting in it, nor dissoluble in water, alcohol, oil, or air. These are the characters of pure Earth; which no more than any of the other elements comes within our reach, free from the admixture of the others; but as it is never made use of in brewing, except sometimes for the purposes of precipitation, it is unnecessary to say any thing more upon it: whoever desires to be more informed concerning it, may consult

Boerhaave, and the authors before-mentioned.

SECTION V.

Of the THERMOMETER.

THE Thermometer is an instrument for measuring the increase and decrease of heat and cold; and, by doing it numerically, fixes in our minds the value of any degree: if bodies of several properties are brought to one denomination, though each possess different degrees of heat, it teaches us to discover what degree they will arrive at when thoroughly blended together, supposing effervescence to have no share in their heat.

The

The inventor of this admirable instrument is not certainly known ; however, the merit of the discovery has been ascribed to several great men, of different nations, in order to do them, or their countries honour. It came to us, from *Italy*, about the beginning of the sixteenth century. The first inventors were far from bringing this instrument to its present degree of perfection ; it was not then hermetically sealed, consequently the contained fluid was, at the same time, under the influence of the weight of the air, and that of expansion by heat. The academy of *Florence* added this improvement ; which soon made them more generally received : but still the instrument laboured under many imperfections ; the high-

est degree of heat of the *Florentine* Thermometer was fixed from the heat of the strongest rays of the sun in that country ; this vague determination, varying in almost every place, and the want of a fixed and universal scale, have rendered all the observations, made with such instruments, useless to us.

Boyle, Halley, Newton, and several great men thought this instrument so worthy of their attention, as to endeavour to fix two invariable points, to reckon from, and to obtain a proper division. Mr. *Amon-*
tons is said to have discovered the uniformity of the degree of boiling water; and made use of this for graduating his Thermometers; but *Fahrenheit* found, that the pressure of
the

the Air would vary this, in its greatest latitude, six degrees; and therefore concluded that a Thermometer, made at a time when the Air is in its middle state, may be supposed sufficiently exact for almost every purpose. As soon as this degree of heat, *viz.* that of boiling water, was settled, many means were proposed to determine another as certain: the degree of temperature was thought, by many, a proper one; but what that degree truly was, became difficult to determine; at last the freezing point of Water offered itself, and though some doubts arose with Dr. *Halley*, and others, whether Water constantly froze at the same degree of cold, yet Dr. *Martine*, by his several experiments, proving this
to

to be beyond all doubt, it has been received for as fixed a truth, as that of boiling Water. These two degrees being thus established, nothing remained but the division of the intermediate space on some scale that could be universally received.

The matter wherewith Thermometers were to be made, became the object of farther search : Sir *Isaac Newton* employed, for this purpose, linseed oil : but this was objected to, as being an unctuous body, and more apt to adhere to the sides of the glass ; and, on account of its being suddenly affected by cold, for want of those parts which thus adhered to the sides, did not shew the true degree.

Tinged

Tinged Water was employed by others ; but this freezing when *Fahrenheit's* Thermometer points 32 degrees, was, from thence, incapable of denoting any cold more intense.

Spirits of Wine, which endure a great deal of cold without stagnating, were next employed ; but this liquor being susceptible of no greater degree of heat, than where *Fahrenheit's* scale shews about 175 degrees, was not capable of being used where boiling Water was concerned.

The only fluid then, which could best answer every purpose, was Mercury ; this never has been known to freeze, and will not boil under a heat of 600 degrees ; beside, it is
free

free from every inconvenience attending other liquids.

I do not recollect to have heard, or to have read, that the exterior form of thermometers has undergone any very considerable alterations ; but as the instrument is entirely founded on the doctrine of expansion, *viz.* that heat or fire expands all bodies, as cold condenses them, there was a necessity of employing a fluid easy to be dilated, whose bulk should be seated in one part, but, being expanded by heat, should shew the expansion by entering into some fine tube, or capillary cylinder, so small that its motion should be speedy and perceptible. Some Thermometers have been constructed with bulbs composed of a larger cylinder :
now

now they are generally made globular; the smaller the bulb is, undoubtedly the sooner is it heated through, and the finer and smaller the tube, the greater will be the length of it, and the more distinct the degrees: but another improvement was still wanting, as it is scarcely possible any glass cylinder, so very small, can be perfect; but if the quicksilver, during the expansion, as in this case it must, passes through some parts of the tube wider than others, the degrees will be shorter in the former, and longer in the latter; consequently, if the divisions in such a tube are made equal between the boiling and freezing points, the Thermometer, thus graduated, cannot be true: to rectify this, the ingenious Mr. *Bird*, of *London*, put into the tube about the
length

length of an inch of Mercury ; and measuring, with a pair of compasses, the exact length of this body of quicksilver in one place, he moved it about from one end to the other, carefully observing, in the several places, how much it increased or diminished in length, and thereby ascertained where, and how much the degrees were to be varied. By this means his Thermometers are perfectly accurate, and exceed all that were ever made before.

I shall not trouble my reader with the number of calculations that have been made to express the quantity of particles the matter contained in the bulb is supposed to consist of, in order to determine the quantity dilated: this Dr. *Martine* seems to think is
more

more curious than useful; it is sufficient, for our purpose, to know how the best Thermometers ought to be constructed: they who have leisure and inclination, may be agreeably entertained by the author last cited.

By observing the rise of the Mercury in the Thermometer, during any given time; as, for instance, during the time of the day, we ascertain the degree and value of the heat of every part of the day: by repeated experiments it appears, that the medium heat of the whole day is usually indicated at a stated time, *viz.* at eight o'clock in the morning, if the instrument is placed in the shade, in a northern situation, and out of the reach of culinary, or any other accidental heat.

Though

Though Water is not so readily affected by heat and cold as the Air, yet as all bodies, that are long exposed to the Air, become of the same degree of heat with the Air itself, no great error can arise from estimating Water, in general, to be of the same heat as the Air, at eight o'clock in the morning, in the shade.

The Thermometer teaches us, that the heat of boiling Water is equal to 212 degrees; and, by calculation, we may learn what quantity of cold Water is necessary to bring it to any degree we chuse; so that though the instrument cannot be used in large vessels where the Water is heating, yet, by the power of numbers, the heat may be ascertained with the greatest accuracy. The rule is this:
Multiply

Multiply 212, the heat of boiling Water, by the number of barrels of hot Water (suppose 22;) and the number of barrels of cold Water to be added to the former (suppose 10 barrels) by the heat of the Air at 8 o'clock (suppose 50;) add these two products together, and divide by the sum of the barrels; the quotient shews the degree of heat of the Waters mixed together.

212 heat of boiling water.		50 deg. of heat at 8.
22 barrels of hot water.		10 bar. of cold water
424		500
22	4664	
10	500	
Sum 32	5164	161 degrees will be the heat of the water when mixed together.
of bar- rels.	32	
196		
192		
44		
32		

The calculation may be extended to three or more bodies, provided they be brought to the same denomination. Suppose these 32 barrels of Water to be used where there is a grist of 20 quarters of Malt: if these 20 quarters of Malt are equal in bulk to 11 barrels of Water, and the Malt, by having lain exposed to the Air, is of the same degree of heat with the Air, in order to know the heat of the Mash, the calculation must be thus continued.

161 heat of Water. 50 deg. of heat of Malt.	
32 bar. of Water. 11 bar. the bulk of Malt	
322	550
483	
32 Water 5152	
11 Malt 550	
43	5702
	43
	140
	129
	119
	129.

133 degrees the heat of the Mash.

We shall meet hereafter with some incidents, which occasion a difference in the calculation, but it will be time enough to mention them by and by.

The Thermometer, by shewing the different degrees of heat of each part of the year, shews us, at the same time, how much, more or less hot, the extracts for common small beer ought to be; what quantity of Hops ought to be used at different times; how much Yeast is requisite, at such times, to carry on a due fermentation; and even the length of the time the Worts ought to boil: and indeed, without this knowledge, Beers, though brewed in their due season, cannot be regularly fermented, and whenever they prove good, it is by accident.

Beers are deposited in cellars, to prevent their being affected by the variation of heat and cold in the external air : by means of the Thermometer the heat of these cellars is ascertained, the temper of the liquor, and whether it will, sooner or later, come forward, determined.

The brewing season, and the reasons why such season is fittest for brewing, can only be determined by this instrument ; it points out likewise our chance for success sometimes in the hottest months.

All vegetable fermentation is carried on in heats between 40 and 80 degrees ; we are, by this instrument, taught to put our Worts together at such a temperature, that they shall
neither

neither be evaporated by too great heat, nor retarded by too great a degree of cold.

If curiosity should lead us so far, we might likewise determine, by it, the particular strength of each Wort, or of every Mash; for if Water boils at 212 degrees, Oils at 600, and Worts be a composition of Water, Oil, and Salt, the more the heat of a boiling Wort exceeds that of boiling Water, the more Oils and Salt must it contain, or the stronger is the Wort.

A given quantity of Hops, boiled in a given quantity of Water, must be similar to the case of the Wort just now mentioned; and their intrinsic value and goodness may in the same manner be ascertained.

F 3 The

The more the Malts are dried, the more do they alter in colour, from a white to a light yellow, next to an amber, then to a high amber; farther on, to a low brown, still encreasing to a higher, until, at last, it become speckled with black; in which state we frequently see it: and if more fire or heat is continued, it will charr, and become black. If once we observe the degree of heat necessary to produce these alterations of colour, we shall, for the future, by inspection of the Malt only, know with what degree of fire it has been dried; know immediately what will suit our purpose, and, with the greatest accuracy, appoint the heat of the first Mash, a thing of the greatest consequence to the right management of the process of brewing.

If

If I had not already said enough to convince the brewer of the utility of this instrument, how curious he ought to be in the choice, and how well acquainted with the use of it, I would tell him, that the heat gained by the effervescing of Malt, is to be determined by it alone ; that heats lost by mashing, or by Water in its passage to the tun, can be found by no other means ; and above all, that there is no other way, with certainty, to know the heat of the tap or extracts ; the importance of which will fully appear in the sequel.

I know very well, that good Beer was made before the Thermometer was known, and still is, by many, who are as entirely ignorant of it, as

F 4

if

if it had never been invented: but this is always by chance; and they cannot but confess they frequently fail; whereas, did they but properly apply this instrument, they certainly never would. It is just as absurd for a Brewer to refuse the use of it, as it would be for an Architect to throw away his rule, as useless, because the first house was, probably, built without one.

SECTION



SECTION VI.

Of the VINE, its Fruit and Juices.

Hitherto we have done little else but define, and consider the properties of the subjects concerned in brewing, occasionally applying them to the art: in the definitions hitherto given of Beers and Wine, we have chosen a diversity, the better to explain ourselves, and convey, at the same time, a true idea of them: we will now consider them as similar, or, at least, analogous liquors. All Wines, whether made from corn or fruit, must, at the time they are used, have their solid parts
so

so blended with their fluid, as to make but one taste, and be sound, light, and transparent : but as this can arise only from a due proportion of the fermentable parts, and from a due fermentation itself, it is evident, that the act of fermentation ought to be the object of our first and strictest inquiry.

Any fermented vegetable liquor, that in distillation yields a spirit which will burn, and may be mixed with Water (says *Boerhaave*) may be distinguished by the name of Wine, whatever vegetable matter it is produced from. Now, as such a spirit is produced both from beer and ales, brewing may be justly called the art of making Wines from corn. In order to arrive at the knowledge of
con-

conducting this art in the best manner, let us have recourse to nature in that liquor, and to that fruit which has wholly engrossed the name of Wine; and observe the properties she employs, and the steps she follows in bringing about the process of fermentation.

Most of the juices of Grapes have, when fermented, the property of being, in time, as light and pellucid as pure Water; and contain fine spirituous parts, sufficient to cherish, comfort, and even inebriate. But these properties in their juices, tho' general, are not universal; for which reason it is necessary to examine some circumstances attending the formation and ripening of this fruit; of those sorts of it, I mean,
whose

whose juices produce a liquor capable of supporting itself in a sound state for some time.

All Grapes, when they first bud forth, are extremely sour, and when ripe, very sweet; being originally an acid, which is afterwards smoothed over with an oil: with us, in *England*, they are produced under the least degree of heat they are capable of, and discover themselves here, in their first shape, about *June*, when the medium of the heat of the sun's beams, and the cold of the night, is nearly equal to 60 degrees, according to *Fahrenheit's* Thermometer; this therefore is the degree of heat, under which their acid salts are formed.

The

The highest degree of heat, in some countries where Grapes come to perfect maturity, as at *Rome*, is 99 degrees; at *Padua* 92 degrees; at *Montpelier* 88 degrees, in the shade; to which, according to Dr. *Linng's* observation, 20 degrees more must be added for the greater heat of the sun's beams: the heat then at *Rome* will be 119 degrees; at *Padua* 112 degrees; at *Montpelier* 108 degrees; and these approach nearly to the greatest degrees of natural heat; for *De Reaumur* has observed no higher than 104 degrees, which, with the addition of the 20 above-mentioned, will make the greatest heat equal to 124 degrees. Hence we may conclude, that 124 degrees is a heat by which their acids are still smoothed with

with oils, so as to become sweet ; and gaining, by the greatest heat, the greatest quantity of oils, they obtain their greatest power, under this degree, of resisting the acids that circulate in the air ; or, in other words, obtain their greatest degree of sweetness. Though the highest degree of heat, in the known world, does not exceed 124 degrees, yet there are many countries, as *Jamaica, Barbadoes, &c.* that will not generally produce grapes ; and whenever the cultivation of the Vine is attempted in those places, it is obliged to be shaded and screened from the scorching beams of the sun, which, in its infancy, it is not capable of supporting. By comparing the heat of those places with that at *Rome, Padua,*
and

and *Montpelier*, as before, it will appear, that the want of Grapes is not owing to the heat being too great to ripen them, but because, in those parts of *America*, the heats, being not only great, but constant, and nearly uniform all the year, exceed the degree of temperature necessary for the first production of the fruit.

Hence we learn, that Nature employs lesser heats to form, than to ripen, the juices of this fruit, or to bestow on them a power of maintaining themselves, for some time, in a sound state. And from this we may learn an invariable rule for our government in extracting the virtues from Malt, for any sort of Beers or Ales whatever. We have investigated the lowest degree of heat in which Grapes
are

are produced, and nearly the highest they ever receive to ripen them ; and knowing, that some climates have a constant heat, too great to admit of their being formed, we may, from these principles, with certainty say, There are certain degrees of heat, with regard to Grapes, which may be called their germinating degrees ; and the rest, superior thereto, their degrees of maturation : and if 60 degrees be the lowest of the one, and 124 degrees the highest of the other ; and if a certain power of acids is necessary for their germination, which must be counterbalanced by an equal power of Oils raised by the heat of the sun for their maturation, or perfect state ; then the medium of these two numbers, or 92 degrees, may be said to be a degree, at which this fruit

fruit cannot possibly be produced. At *Panama* the lowest degree of heat is 72 degrees, to which 20 degrees added, for the sun's beams, makes 92 degrees, consequently no Grapes grow there: if we recollect, that we can scarcely make Wine, which will preserve itself, of Grapes produced in *England*, (for our sun seldom raises the Thermometer to 100 degrees, and that but for a short continuance) and that the sun, with us, at several distant terms in summer, is seen to produce new germinated Grapes, it will confirm all that has been advanced above. These reflections are of use in brewing; and likewise point out, to us, what parts of our Plantations are fit to produce this fruit, and to what degree of perfection.

G

I have

I have been the more particular in this point, because there is a great similarity between the growth and ripening of Grapes, and the drying and extracting of Malts. If too small a degree of heat is made use of, acidity ensues; if too great, on account of a large quantity of air being expelled by the heat, no extract can be obtained. Nature alone points out, to us, the best and wisest rules; in this fruit, she shews us, that the power which forms it, is exerted only to a certain number of degrees of heat; and that its maturation likewise depends on a similar extent of heat, but greater, and more powerful.

In order to illustrate the doctrine, that Grapes are endued with various properties, in proportion to the heat
of

of the air they have been exposed to, let us remember what *Boërhaave* has told us, that, in very hot weather, the oleous or pinguious corpuscles of the earth are carried up into the air, and descending again in the next shower, make the rain, in summer, very different from that pure snow which falls in a hard frost: it is far more acrid, and disposed to froth; and hence summer rain, or rain produced in hot weather, is always fruitful, whereas that in cold is scarcely so at all. In winter the air abounds with acid parts, and is more compressed by cold; in summer, as may be seen not only from the rain's disposition to froth with acid salts, but also with oily or pinguious corpuscles, it is in a more relaxed state. The same writer has observed, in many places,

that principles which once occupy bodies, are so blended one with another, as to be ultimately inseparable: thus Grapes, by cold, obtain a quantity of compressed air, which, when covered with oils attracted into the fruit by a greater heat, becomes, in some degree, elastic; from hence arises (as we shall hereafter see) part of their fermentable quality: and as Grapes gain also acid parts, which cannot, by any natural heat, be entirely removed, but are covered or blended with oils attracted by heat, a saccharine salt is formed. Now, in proportion as these acids are formed more or less sharp, and counterbalanced by a greater or less quantity of oils, their juices approach nearer to perfection or saponaceousness, and complete the power of fermenting.

ing. A perfect fermentation is the aim of the Wine-maker ; and as this cannot be obtained but with juices perfectly saponaceous, it follows, that the properties of a true sapo may be estimated by the same scale and numbers as fermentation ; and a sapo may be said to be true and perfect, when the power of the salts therein are equal to the power of the oils, and both most intimately blended ; from whence Wines ferment, become spontaneously pellucid, and maintain themselves sound a due time. A reflection on the different tendency the Wines of *France*, *Spain*, and the *Madeiras* have to these properties, in proportion to the heats they sustain in several stages of growth, and some Wines, which come from the *Indies*,

which art can scarcely make transparent, will evince the truth of this doctrine; so that it may well be noted, that chemistry has not furnished the practical part of the brewing, with a better piece of intelligence than this.

The nature of the soil proper for the Vine would, in another work, be a very useful enquiry; it will be sufficient here barely to hint at the effect which nitrous soils produce in musts. The *Portuguese*, when they discovered the island of *Madeira*, in 1420, set fire to the forests with which it was totally covered; it continued to burn for the space of seven years, after which they found the land extremely fruitful, and yielding
such

such Wines as, at present, we have from thence, tho' in greater plenty: now *Madeira* Wines are very difficult to fine, and though this climate is more temperate than the *Canaries*, yet the Wines are obliged to be carried to the *Indies*, and the warmer parts of the Globe, to be purged, shook, and attenuated to the same degree of fineness as other Wines; tho', were the *Portuguese* masters of fermentation, much, or the whole of this trouble might be avoided. Hence we see, that nitrous soils will produce Musts able to support themselves longer, and resist acidity more than other soils under the same degree of heat. These considerations, and others of a like nature, will partly account for the different taste we find in this liquor.

Grapes have the same constituent parts as other vegetables: the difference between them, when in perfection, as to their tastes and properties, consists in the parts being mixed in different proportions; this arises either from their absorbent vessels more readily attracting some juices than others, or from their growing under different heats, and in different soils.

We find (says Dr. *Hales*) by the chemical analysis of vegetables, that their substance is composed of sulphur, volatile salts, water, and earth; which principles are endued with mutual attracting powers; and also a large portion of air, which has a wonderful property of attracting in a fixed, or of repelling in an elastic, state, with a power superior to vast

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compressing forces; and it is by the infinite combinations, action, and reaction, of these principles, that all the operations in animal and vegetable bodies are effected.

Boerhaave, who is somewhat more particular with regard to the constituent parts of vegetables, says, they contain an oil mixed with a salt in form of a sapo, and a saponaceous juice arising from the mixture of water with the former.

It is very difficult to judge, by the taste or sight, how strong a *Must* is, or, according to *Boerhaave's* expression, how saponaceous it is. In worts the bubbles are durable in proportion to the tenacity of the liquor; in strong worts more; in weak ones, less: but
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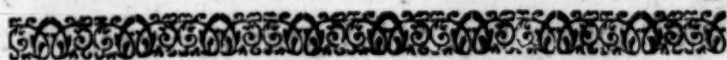
this is far from determining the degree of saponaceousness; and hence, in brewing, arises the necessity of applying the Thermometer to the extract itself, to determine whether it be properly made. Friction neither adds to, nor takes away from the perfection of a Must; for tho' it generates many air bubbles, yet it neither alters the composition, nor increases or lessens the tenacity.

Grapes; from the nature of their composition, have all the necessary principles to form a sapo; they abound with elastic air, water, oils, acid salts, and even saponaceous juices; but the air, enveloped by the covering of the fruit, lies inactive, till it is moved by some foreign cause: in this confined state it causes no visible

ble motion; nor are the principles, thus confined, subjected to any apparent impressions of the external air, or so intimately mixed as when the juices of the fruit are expressed; but as a perfect mixture of these principles is necessary for the formation of a *sapo*, it is clear, this cannot be perfected without a free communication of the external air with that contained in the interstices of the liquor. The air contained in the interstices of fluids is more in quantity than is commonly apprehended, for Sir *Isaac Newton* has proved, that Water has forty times more pores than parts; and tho' this porosity in liquids suffers the first act of fermentation to arise, yet we must observe, that there are circumstances under which Musts cannot ferment, *viz.* when

when the heat of the Wort, to be fermented, exceeds 80 degrees, or is less than 40 degrees ; or when the Musts are so overloaded with oils, that the acid parts of the air are too weak to penetrate them ; for the ultimate particles of the air, says *Boerhaave*, cohere together in such a manner as not easily to insinuate themselves into small passages. Much more might be said on the subject of the Grape ; but I chuse to confine myself chiefly to those particulars, which have some relation to, or may afford us any light in, the art of brewing. The act of fermentation, in all vegetables, is undoubtedly the same ; let us observe then, how it is carried on by Nature in the juice of the Grape, in order to apply many things, that may be learned from
thence,

thence, to the business of ales and beers.



SECTION VII.

Of FERMENTATION.

FERMENTATION is that act, by which oils, and earth, naturally tenacious, and rendered still more so by their mixture with acids, are brought to such a degree of fluidity, as to be equally suspended in an homogeneous, pellucid fluid; which, by a due proportion of both principles, is preserved from precipitation and evaporation. According to the accurate *Boerhaave*, a less heat than forty degrees leaves the mass in an inert state, and the particles fall to the

the bottom in proportion to their gravity : a greater heat than 80 degrees would disperse them too much, and leave the residuum a rancid, acrimonious, putrid mass.

In order to point out the cause of Fermentation, let us trace its several stages ; and the effect of the air will, in great measure, account for them as they rise. The Must, when just pressed from the Grapes, is a liquid composed of acids, oils of different spissitude, water, earth, and elastic air. These are irregularly ranged, and, if I may be permitted the expression, compose a chaos of Wine. Soon after the liquor is settled, a number of air-bubbles arise, and, at first, adhere to the sides of the containing vessel : their magnitude en-
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creases as they encrease in number, till at last they cover the whole surface of the Must.

It has been long suspected, and, if I mistake not, demonstrated, that an Acid, of which all others are but so many different species, is universally dispersed thro', and continually circulating in the air; and that this is one of Nature's principal agents in maturing and resolving bodies. Must, like other fluids, being porous, the circulating acids are very powerfully introduced into it by the pressure of the atmosphere, and in proportion as the pores of it are more or less expanded by the heat it is exposed to. The particles of Acids, says Sir *Isaac Newton*, are endued with a great attractive force,

force, in which their activity consists : by their attractive force they rush towards other bodies, put the fluid in motion, excite heat, and violently separate some particles in such a manner as to generate air, and consequently bubbles.

As soon as the acid particles of the air are admitted into the Must, they act on the oils, and excite a motion somewhat like the effervescence generated when acids and oils come in contact, tho' in a less degree ; they also excite heat, by means of which the included elastic air is rarefied, and ascends in bubbles towards the surface : these, by the power of attraction, are drawn to the sides of the vessel ; at first they are small and few, but encrease, both in number and

and magnitude, as the effect of the air increases, till, at last, they spread over the whole surface. The first act then of vegetable Fermentation appears to be, the motion by which part of the elastic air is freed from the Must. It may, perhaps, be proper to observe, that all Musts, which ferment spontaneously, contain a quantity of elastic air.

Bubbles still continue to rise after the Must is entirely covered with them; and a body of bladders is formed, called, by the Brewers, the head of the drink; which, by retaining the internal heat excited by the motion, accelerates the fermentation. As the number of bubbles increase, the head rises in height,

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and continues in this state till the compound particles are separated from one another : after this the bubbles (the Must being more attenuated) rise almost in right lines, but not exactly so, and thereby force the head to take an uneven and irregular shape, so that it appears like a beautiful piece of rock-work. It may be presumed, that at this time the constituent parts of the Must are disposing themselves in their due order, and that the interposition of the Water keeps not only the saline, oily, and spirituous parts, but also the mucilaginous and earthy ones, in their due arrangement. Heterogeneous bodies, as dirt, straw, corks, &c. are now buoyed out of the Must, and should
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be skimmed off, left, when the liquor becomes more light and spirituous, they should subside. As the heat increases, the air-bubbles grow larger; some not formed of parts so strong as the others, which generally are the first, burst and strengthen the rest; by which means, as thereby the internal heat is better retained in the fermenting liquor, the fermentation is capable of being carried to a farther degree of perfection; its particles now become more poignant and powerful, its volatile ones fly off, the laws of motion begin to take place, the heavy parts subside, the lighter ascend in right lines, and the rocky head, which before covered it, becomes uniform again, but of a

greater volume. The Wine, by being more attenuated, is at last unable to support, on its surface, the weight of such a quantity of froth, rendered still more dense by repeated explosions ; for which reason the liquor, lest it should be fouled by the falling in of the froth, ought, at this juncture, to be put into vessels, or casks, having only a small aperture. In this state it will continue to ferment, with a slower, and less perceptible motion, even when the bung-hole of the cask is stopped, should it, by any other means, gain the least quantity of external air ; and if the Must was perfectly saponaceous, it will continue to ferment until it becomes fine and pellucid.

It

It is easily conceived from hence,
That a cold air, closing the pores of
the liquor, must retard the act of
fermentation, as heat forwards it :

That Musts charged with oils ferment with more difficulty, and require a longer time before they become perfectly saponaceous and fine :

That Musts charged with still larger quantities of oil, so as to exceed the power of their own acids, and of those that are absorbed in fermenting, require a still longer time before they can become pellucid, unless assisted by precipitation : and that there may be cases, where even precipitation cannot fine them.

This naturally leads us to another division of Wines ; into such as soon grow fine, and soon become acid, being the growth of cold countries :

Such as by a due proportion of heat, both when the Grapes germinate, and when they come to maturity, form a perfect saponaceous Must, which will not only preserve itself, but, in due time, become fine :

And such, as, having taken their first form under the highest degrees of germination (as I termed them) being more replete with oils, disappoint the cooper, and render the application of menstruums useless, unless in such quantities as to change the
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the very nature of the Wine. Proofs of what I have here asserted, may easily be collected from considering the Wines made in *England*, in *France*, in *Portugal*, or *Spain*, at the *Madeira's*; and such as come from the *Indies*, which are never bright.

The great difference then in Wines arises from the climate; and a similar difference in Beers arises from the different degrees of heat the Malt has been exposed to in drying, or extracting.

Fermentation continues in a Must which is perfectly saponaceous, even after its first process of becoming fine; for every fretting is a continuance of fermentation,

tion, though often almost imperceptible; the oils become more attenuated, and less capable of retaining the elastic air: this is often the case after the liquor is pellucid; so that it is impossible to determine, by any rule, the exact state in which Wines should be, in order to be perfect for use. Both Wines and Beers, when new, possess more elastic air, than when meliorated by age; how this must affect the human body, the physical Gentlemen best know: decisions of this sort exceed the Brewer's province, which seems confined within the bounds of taste, which chiefly depends on the palate: however, thus much may we venture to say for Wines, or any fermented liquors, To be wholesome, they must be possessed of the whole
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of their fermentable principles : for which reason Beers or Ales, when substituted for Wines in common, but more especially when given to the sick, should always be brewed from entire Malt : for the last extracts, possessing but the inferior virtues of the grain, have by so much less the power to become light, spirituous, and transparent ; and that every kind of fermented drink absolutely ought to be so, Nature herself points out to us.

It sometimes happens, that tho' the Must is greatly overloaded with oils, yet there is a greater tendency to fermentation than to putrefaction. In this case, time will get the better of the disease. This sometimes happens (though in a lesser degree) in Wines of the growth of a too hot sun ;

fun ; they are, for some time, faint and sick, but often recover by heat : more frequently is this the case in Beers extracted by too hot a liquor, or overcharged with Hops : these, at a certain period, sicken, smell rancid and disagreeable, but, by long standing, they first fret, and then receiving more acids from the air, recover their former health and taste.

If the fermentation still continues, the liquor becomes acid ; most of the oils of the Must, and most of its elastic parts having spent themselves, and their places being supplied by acids from the air : in this state it is Vinegar.

Its last stage, or termination, is when, the remaining active principles

ples the Vinegar possessed, being absorbed in air, a pellicle forms itself on the surface of the liquor, and dust and seeds, which always float in the medium, depositing themselves thereon, strengthen this film into a crust, on which grow moss, and many other vegetables, which, together with the Air, exhaust the watery parts, no sign of fermentable principles remain; and, like the rest of created beings, all its virtues being lost, what is left obvious to our senses, is a substance resembling common earth.

Upon the whole, then, it appears, that a liquor fit for fermentation must be composed of water, acids smoothed over with oils, or saccharine salts, and a certain portion of elastic

elastic air; that the heat of the air the liquor is fermented in, must be in proportion to the density of its oils, that the pores may be expanded by slow degrees, lest the air, by being admitted too hastily, or quick, should cause an effervescence rather than a fermentation, and turn the whole acid. For these reasons, Wines fermented in countries where the autumn is hot, require their oils to be more pinguious than where the season is cooler. For the same reason, Beers are best made when the air is at forty degrees of heat, or below the first fermentable point, because then the Brewer can put his Wort to work at a heat of his own chusing, which will not be augmented by that of the air; but, on the contrary, when by its internal motion

tion its heat is encreased, it will again be abated and regulated by the cold of the medium.

The acids in the air are blunted by the oils in the Must, consequently when the acids are conveyed in a greater proportion into the Musts, the Must ought to be charged with a greater proportion of oils; for this reason, small beer brewed in summer, when the air and the acids more easily insinuate themselves into the liquor, ought to be enriched with oils by hotter extracts; and in winter the contrary method must be pursued.

Wines are sometimes vapid and flat, but not sour; this does not arise from their imbibing the air, but from their fermenting and generating too much

much air ; for which reason they are best preserved in cool cellars, whereby their active, invigorating principles are kept within due bounds, and not suffered to fly off.

Musts overcharged with oils, instead of fermenting, putrefy, even though, by means of yeast, elastic air has been conveyed into them. The over-proportion of oil, and its tenacity, prevent the entrance of the acids, the Must cannot receive any enlivening principle from without, and the air the yeast conveyed into it, is enveloped with oils so tenacious as to be incapable of action ; for nothing so much accelerates putrefaction as heat, moisture, and stagnating air ; and all substances corrupt, sooner or later, in proportion

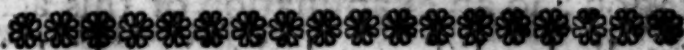
to their mixture with air, to the vent they have, and the closeness of their confinement.

Ferments in general, such as yeast, flowers or lees of wine, honey, the expressed juices of ripe fruit, are only subjects more or less replete with elastic air, conveying the same to the Musts that stand in need of it. As these are liable to be tainted externally by corruption, and internally with regard to the nature and contents of the elastic air, great care ought to be taken in the choice of them. *Boerhaave* has ranged these, and several other, in different classes, in proportion to their fermentable powers, or rather in proportion to the quantity of air they contain for this purpose. Every imperfection in the ferment

ferment is so readily communicated to the Must, that it would not be an improper question to be determined by physicians in a time of sickness, whether the use of those which have been made in infected places ought to be permitted; and whether, at all times, drink fermented in a pure and wholesome air is not preferable to that which is made among fogs, smoke, and nauseous stench^{*}.

* By Dr. HALE's experiments made for discovering the proportion of Air generated from different bodies, it appears, that Raisin Wine in fermenting absorbed a quantity of Air equal to nearly one third part of its substance; and Ale, under the like circumstances, absorbed one fifth.

SECTION



SECTION VIII.

Some farther Thoughts on FERMENTATION.

IN the foregoing section I have endeavoured to relate the process of Fermentation, as it arises from Musts that are most perfect for this act, and whose Wines, to become light and pellucid, require time only, and no additament. Nor have I deviated from this plan, except as I found opportunity to apply its principles to the Brewery: but as, in the art of Brewing, there is no part so difficult, and at the same time so important to be understood, as the cause and effects of Fermentation ;

tation; so an examination of this act, in all the different lights in which it offers itself to our notice, must be thought interesting.

The Musts of Grapes, when fermented, form more Lees than those from Malt do; and thus this shews, that they possess their elastic Air in a greater number of much stronger, though smaller, vessels; which, in general, would be an argument of their being capable of preserving themselves longer in a sound state; for the more powerfully Air is enveloped in the Must, the more frettings, and the greater attenuation of the Oils does the Wine require before the Air can be absorbed. Now, this great quantity of elastic Air resided originally in the fruit; whereas

whereas Malt, by the Barley being first saturated with Water, and then dried, hath its Air, in part, driven out ; for the heat which performs the operation of Malting, much exceeds the limits of Fermentation ; and the expulsion of Air from the Worts of Beers and Ales is still further effected by the extracts from Malts undergoing a long boiling, which occasions the necessity of replacing their elastic Air by the addition of Yeast, in order to their becoming fermentable : in which process, when duly carried on, the Musts of Malt produce, generally, two gallons of Yeast from one quarter of the grain ; whereas, in the coldest fermenting weather, one gallon of Yeast is sufficient to work that quantity. Much elastic Air still

remains in Beer, or Wine from Corn, after the first act of Fermentation is over, and the liquor is separated from the Yeast above-mentioned, as it is then neither flat, vapid, nor sour : so that if we say, Malts, by their being dried, and having their extracts boiled, lose only one part in three of their Air, we shall, perhaps, not be very far from the truth. But as the lost Air, just mentioned, is replaced only by Yeast, it must be observed, that Yeast, or the flowers of Malt liquor, are of a weaker texture than those of Grapes, and consequently the elastic Air in the bubbles not so much compressed. This arises from their Oils being less tenacious, from their first Fermentation being performed in a much shorter time, and from the greater heat

heat of the Fermentation which produced the flowers: they are also more equal in size. From these causes their effect is more speedy; insomuch that were the Air-bubbles produced from Malt, and applied to a Must, to be equal in number to those in the same quantity of unfermented juice of Grapes, their quick explosion would cause an Effervescence, and not a Fermentation; by which means the liquor would soon sicken, and be void of every enlivening principle: for this reason all artificial Fermentations should be carried on in the slowest and coolest manner possible, especially where drinks are intended for keeping; and for the like reasons they will not bear to be so often drawn off, or deprived of their lees, as natural Wines; in my opinion this

ought not to be done at all, unless, for some defect, they are to be blended with fresh Worts under a fresh Fermentation.

The different Fermentations may be said to be, at least, as various as the several spaces of time, which Wines formed from Grapes, or any other vegetable, require, before they come to the proper degree of perfection for use: the enumeration of them is as endless as unnecessary; but, to come nearer to our purpose, Fermentation may be divided, not improperly, into Natural and Artificial: the first is, when it rises spontaneously, so as to answer all the necessary purposes; and the other, when it is assisted by what we generally

rally term Ferments, or the substitutes requisite to excite the act *.

* This division I chuse, as most convenient to my present purpose; for undoubtedly there are liquors, which tho' they have of themselves the fermentative properties, and naturally performed the act, yet, either thro' want of transparency, or of such properties as would enable the Wine to maintain itself in a sound state, so as to be meliorated by time, are more defective than such as are made to perform the act by substituted Ferments: and some artificial Fermentations there are, in which Ferments are so duly administered, that, in the end, they approach very near, and even vie with the most perfect natural Fermentation. Were I to enter into a more minute detail, it might be shewn, that Wines, when transported from a hot climate to a cold one, are often thereby so impeded in this act, as, from thence, to become imperfect; and that Beers removed from this to a more southern region, are often improved, and sooner brought to be fit for use; but though canvassing such ideas might enlarge and improve our conceptions of this act, to indulge them, at present, would exceed the bounds and design of this Essay.

All vegetable substances possess fermentable principles, though in a diversity of proportions; but those juices only which are of such a nature as to arrive at some degree of perfection in proportion to the quantity of their fermentable principles, can be made into Wines. I would not, from what I have before said, be understood, as if vegetables were more or less acid, or more or less sulphureous, from the heat of the climate they grow in. This, though one of the reasons of their being so, is not the only one; the form, make, and constitution of the plant is another; for in very hot climates are produced acid fruits, such as Limes, Tamarinds, Lemons, and Oranges, whose fermentable properties are such, as to be very far from making

making sound Wines, though, in some degree, they may be susceptible of Fermentation; and even in those countries, so greatly favoured by the sun, they have Vines of such a nature, as to attract the acids from the Air and Earth so greedily, that, when their juices are fermented, they soon become sour: and, on the contrary, in cold climates we see warm aromatic vegetables grow, such as Hops, Horseradish, Camomile, Wormwood, &c. whose fermentable principles are such, that not without difficulty, perhaps not perceptibly, would they ferment. These instances are to be accounted as extremes; for in cold countries, equally as in hot, fruits are produced susceptible of a perfect fermentation, as Apples, some species of which are
endued

endued with such austere and aromatic qualities, that their expressed juices are capable of spontaneously fermenting until they become pellucid, and capable of remaining in a sound state many years. From hence it appears, that proper subjects, which will naturally ferment for making Wines, may be found in almost every climate. *England*, says *Boerhaave*, is, on this account, remarkably happy: her fruits are capable of producing a great variety of Wines, equal in goodness to many imported, were not our tastes, perhaps, made subservient to our prejudices.

The effect of the act of Fermentation on liquors, is so to attenuate the oils of vegetables, as to cause them

them to become spirituous, and easily inflammable. When a Wine is dispossessed of such Oils, as is nearly the case in Vinegar, far from possessing a heating or inebriating quality, it becomes a remedy against intoxication, and refreshes. Thus the term of Fermentation should be applied only to that act which occasions the expressed juices of vegetables to become Wine: but as several acts pass under the name of Fermentation, it may not be improper to distinguish them here according to these principles.

Vegetation, one of them, is the act wherein more Air is attracted, than is repelled. I believe all that hath been said above concerning the juices of Grapes, is a convincing proof thereof.

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Fermentation is where the communication of the external and internal Air of a Must is open; and, when in its perfect state, the power of repelling is equal to that of attracting Air.

Putrefaction is when, by the power of strong Oils, or otherwise, the communication between the external and internal Air is cut off, so that the liquor neither repels nor attracts, but, by an intestine motion, the united particles separate, and tend to fly off.

Effervescence is when, by the power of attraction, the particles of matter so hastily rush into contact, as to generate a heat which expels the inclosed Air; and this, more or less,

less, in proportion to the motion excited.

Hitherto I have considered Grapes as a moist pulpos fruit, sufficient of themselves to furnish Water for extracting their other parts ; but the natives of the countries where this fruit abounds, in order to preserve them, as near as possible, in their primitive state, suspend them in the sun, or place them in ovens, to dry ; by which means being, in a great measure, divested of their watery particles, they remain almost inactive, without juices sufficient to form Wine, unless Water be added to them ; which element becoming, in that case, a substitute, might, from thence, be said to be a ferment, and con-

consequently this might be accounted the first class of artificial Wines.

In all bodies, from the various proportions of their constituent parts arise different effects: thus, from hence, they are, more or less, in a durable state, and accordingly tends either to Inaction, Fermentation, or Putrefaction. Now, by a judicious substitution of such parts as shall be wanting to bodies, they may be restored to their pristine nature; as may be plainly proved by the observations and experiments communicated to the public by Dr. *Pringle*. Thus Grapes, though dried and exported from their natural climate to another, by the addition only of Water, ferment spontaneously, and form Wines, very near alike to such as they

they would have produced before ; and it may with confidence be said, that when any visible difference appears therein, it arises from the injudicious manner in which the water is administered, from the fruits not being duly macerated, or from want of such heat being conveyed to the water and fruit, as the juices would have had, had they been expressed out of the Grapes when just gathered ; often from the whimsical mixture of other bodies therewith ; and perhaps from the quantity of bad Brandy, which is always put to Wines abroad, to prevent their fretting when put on board ship : so that, upon the whole, tho' some small difference is often observed, it doth not make void the fact, that a due quantity of water being applied to dry Raisins, an extract

tract may be formed, which will be impregnated with all the necessary constituent parts the Grapes had in them when ripe upon the Vine, and will consequently ferment spontaneously, and make a vinous liquor.

Vegetables in their original state are divisible into the pulpous and farinaceous kinds, both possessing the same constituent parts, tho' in different proportions. Now, if from the farinaceous such parts be taken away as they superabound in, and others be added in which they are defective, these vegetables may, by such means, be brought to resemble, in the proportion of their parts, more especially in their Musts, the natural Wines I have before been treating of;

of; which being universally acknowledged to be the standard for Wines, the nearer any fermented liquor approaches thereto, by its saponaceousness, lightness, transparency, and taste, the greater must its perfection be,

To enquire which of the pulpous, or which of the farinaceous kinds of vegetables are fittest for the purpose of Wine-making, would be but an unnecessary digression. Experience, the best of guides, hath, on one side, given the preference to the Vine, and on the other to Barley. To make a vinous liquor from Barley, having all the properties of that produced from the Grape, is a task which can only be compassed by making use of such methods, that the Wort of these shall resemble the Must produced from the

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other ;

other ; for whatever different means have been practised to flatter particular palates, to heighten the pungency, or encrease the strength, of Beers and Ales, the success has but rarely answered the intent ; as the more complicated a process is, the more it is liable to be erroneous : and this the legislative power hath wisely discountenanced, seeing the grain brought to a fermented state, but more especially when Hops are added thereto, is sufficient to answer every useful and necessary purpose as a vinous liquor.

Ales, by some, are taxed with being viscid ; and Beers have been said to contain igneous particles. The most certain marks of wholesomeness in Wines, are transparency and
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lightness ; yet some, which are rich, more especially Malt liquors, though perfectly fine, have been said to be viscid : transparency appears, in many Wines, before the Oils are attenuated to their highest perfection, as we have before remarked ; where the powers of the Oils and Salts are equal, which is denoted by the brightness of the liquor, viscosity can arise only from the want of age : in this case it is not a defect, but a misapplication of the liquor, by using it too soon.

As to Malt liquors retaining igneous or fiery particles, Malts dried to keep have undoubtedly their particles removed, by Fire, beyond their sphere of attraction, else they would

not be in a fit state to preserve themselves sound ; for which reason, when they first come into contact with the Water which is to extract them, they cause an effervescent heat, which only adds to the extracting power, and should be looked on, by the Brewer, as an auxiliary help ; but that Fire should be retained either in the Malt or the Must, is impossible. Fire itself is of so subtile a nature, that its particles, when contained in a body, continually tend to fly off, and mix with the surrounding Air ; so that only an equal degree, with what is in the atmosphere, can be continued in the grain, or any liquor whatever, after it has been, for some time, exposed therein. Brown Beers, which are made from Malts more dried than

than any other, are, from experience, found to be less heating than the liquors brew'd from pale Malt; which probably arises from hence, that brown Beers contain a less quantity of elastic Air than pale Beers, as pale Malt liquors contain less than Wines produced from vegetables in their natural state; and not only so, but as Malt liquors contain their elastic Air in bubbles of a weaker consistency than those made from the juices of Grapes, the effect of Malt liquor, when taken in an over-abundant quantity, is neither of so long a continuance, nor so powerful, as that of Wine, supposing the quality and quantity of each to be equal. Tho' to some it may appear the effect of prejudice, yet it is but justice to the

produce of my country, to add, that some Physicians have given it as their opinion, that strong drinks from Malt are less pernicious than those produced from Grapes. So much, I hope, I may say, without being thought guilty either of assuming too much, or of countenancing debauch, by pointing out the Wines that occasion the fewest disorders.

SECTION



SECTION IX.

Of the Nature of BARLEY.

BARLEY is a spicated, oblong, ventricose seed, pointed at each end, and marked with a longitudinal furrow. The essential constitution of the parts in all plants, says Dr. *Grew*, is the same: thus this seed, like plants which have lobes, is furnished with radical vessels, which, having a correspondence with the whole body of the Corn, are always ready, when moistened, to administer support to the plume of the embryo, or what is usually called the acrospire. These radical vessels, at first, receive such nourishment from

a great number of glandules dispersed almost every where in the grain, whose pulpous parts strain and refine such food almost to a vapour, and so fit it to enter the capillary vessels; and such an abundant provision is made for this nourishing of the plume, that the same author says, these glandules take up more than nine tenths of the feed.

It is sown about *March*, sooner or later, according to the soil that is to receive it, and generally reaped in ten or twenty weeks time: most plants, which so hastily perform the office of vegetation, are remarkable for having their vessels proportionably larger; and that these may be thus formed, the seed must contain a greater quantity of tenacious Oils,
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in proportion, than those seeds, whose vessels being smaller, require more time to perform their growth, and come to maturity. Barley also, as may be observed, grows and ripens with the lower degrees of natural heat; from whence, and from the largeness of the size of its absorbent vessels, it must receive a large portion of acid parts. Thus is it said to be viscid, though, at the same time, a great cooler, Water boiled with it being often drank as such; it is certain, that however it be prepared, it never heats the body when unfermented.

From these circumstances of its being viscous and replete with acids, it would, at first, appear to be a most unfit vegetable, from which vinous liquors,

liquors, to be long kept, should be made ; and indeed the extracts made from it in its original state are not only clammy, but soon become sour.

In its state of full maturity its constituent parts seem to be differently disposed, than when in a state of vegetation ; for then the oils or balsams, which sheath its turgid vessels, are lodged in order in their cells, which when it vegetates by abounding with acids, these oils readily become fitted to enter and swell its radical and capillary parts. By germination alone all its principles are put in action ; the fibrous parts, which are not dissoluble in Water, possess themselves of a great quantity of tenacious oils, leaving the glandules and finer vessels replete with water, salts, and
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the purest sulphur. If, in this state, the Corn is placed in such a situation, that, by heat, the acid and watery parts may be evaporated, the more such heat is suffered to affect it, the the more dry, and less acid will the Corn become, and its parts being divided by germination and heat, its viscosity will be removed ; its taste will become saccharine by the acids being lessened in proportion to the Oils, and these be more tenacious, as they have received more heat. This process, regularly carried on, is what is termed *Malting*, which I shall endeavour to explain more at large.

But, before we enter thereon, it will be necessary to consider the state of the grain as it comes from the field.

field. When reaped, though, upon the whole, it may be said to be ripe, yet every individual part, or every Corn cannot be so: and this, in some seasons, is so remarkable as to be distinguished by the eye. The different situations, the winds that have reigned, the shelter some parts of the field have had from such winds, the weather, and difference in the soil, account for this. However, when the greater part of the Corn is supposed to have come to maturity, it is cut and stack'd; the ripest parts having the least moisture, and the fewest acids; and the greenest the greater share of these. In this state the unripe part of the Corn, whose acids attract, and are greedy of water, communicate their moisture to such as are more dry, which acting on their
Oils,

Oils, an agitation ensues from hence, more or less gentle, in proportion to the power of the acids and water; and from this motion arises a heat proportioned to the action; so that there is no determining the exact degree such heat will arise to. When this sweating in the Mow is kept within its due limits, the whole body of the Corn, after the ferment is over, becomes of one equable dryness, and is not thereby discoloured; but if put together too wet or green, the heat thereby occasioned will destroy the very power of germination, as the Farmer, to his loss, will experience; for by encreasing, and from want of Air recoiling repeatedly, it will blacken, or rather charrs the grain, and often burst out into actual flame.

The

The effect a moderate and gentle ferment of this sort must have on the Corn is that of pressing its Oils towards the external parts of its vessels and skin ; by this means it comes into a state more capable of preserving itself against the injuries of the weather ; and the more it is in this state, the more backward will it be to germinate when used for that purpose ; if carried too far, as we have before seen, by such heat the plume and root of the inclosed embryo must be quite scorched, and thus the Corn will become inert, and incapable of vegetation. What degree of heat will produce this effect, I will not immediately determine, but apprehend it to be when the particles of the grain are removed from each other beyond their sphere of attraction ;

tion ; which experiments on Barley shew to be at about 120 degrees.

Vegetables, in general, may be said to be susceptible of a large latitude in this respect, according to their different textures ; so that this degree of heat may, perhaps, be applicable only to Barley, as the seeds of some Grapes bear 124 degrees of heat, and may be capable of being impressed with more, and yet vegetate : but surely, if the Oils of the Corn be made so tenacious as thereby to be discoloured, the seed can scarcely be revived ; and this happens to seeds, sooner or later, by heat, in proportion to the cohesion of their parts, and their weight. But this is a point more properly to be judged of
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of by the colour of the grain, and is more immediately the business of the Farmer and Maltster, than of the Brewer.

Thus, though it may be disadvantageous to the Maltster to steep grain, which has not sweated in the Mow, as, from hence, it will not equally imbibe the Water; so Barley that is over-heated, or *Mow-burnt*, is not fit for his purpose; and it is scarcely possible any large quantity of Barley, from the stack, should equally make perfect Malt, as the heat, generated on its being thus put together, is always greatest in the centre of the Rick, and considerably more so than in its exterior parts.

M A L T.

M A L T I N G.

This process begins with the proper means for setting the constituent principles of the grain in motion; so that the Oils, which before served to defend the several parts, may be enabled to take their proper stations. This is effected by steeping the Barley in Water, where it strongly attracts moisture, as all dry bodies do; but it requires some time before the grain is fully saturated therewith, as two or three days, more or less, in proportion to the heat of the Air: for vegetables receive the water only by its straining through the outward skin and absorbent vessels, whose texture, though dry at first, yet hath its pores so very fine, that they require

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this

this element to be reduced almost to a vapour, ere it can gain admittance; and heat hath not only the property of expanding such pores, but, perhaps, that also of rendering Water more fit to make its way into them.

When the Barley is fully saturat-
ed, though a great quantity of Air
is expelled from it, as appears from
the number of bubbles which arise
on the surface of the water, yet still
much remains in the Corn. A judg-
ment is formed of the crisis, when it
can imbibe no more of the watery
element, from its turgidity and pul-
pousness, which occasion it easily to
give way to an iron rod dropped per-
pendicularly into it. Then is the Wa-
ter let go, or drawn off, the grain is
taken

taken out of the cistern, and laid in a regular heap : here, for the same reasons as Hay, or any other moist vegetable, when stacked together, grows hot, so doth this heap of Barley. The Air compressed in its glandular parts and vessels by moisture, and warmed by the intestine motion, expands, and with this force expels their Oils from the capillary vessels into the roots, in order to fill, extend, and dispose them to seek and receive nourishment for the embryo or acrospire, which while the root is procuring, the plume is softened with moisture from the glandular parts. The root, having received some power (before it expands its fibres) by its heated elastic Air, presses the Oils into the acrospire, which are replaced by the seminal vessels furnishing all

they are able into the roots to forward the action. But that the Corn in the heap may not acquire too great a degree of heat, and carry on the germination too fast (by which means the finer parts, with which the cellules are replete, would not only be wasted, but be so heated as to intangle with them the coarser Oils of the grain, which would occasion the Malt, when made, to be bitter, and ill tasted) it is then, at a due temperature, dispersed in beds on the floor of the Malt-house, and gradually spread thinner and thinner, being frequently turned, from time to time, in proportion as it is, more or less, slow in growth, so that it may come tolerably dry to the kiln, in such a state that its fibrous roots shall be spread, and the spire be near coming

coming thro' the skin of the Barley ; by which the Maltster is satisfied, that every part of the grain has been put in motion, and separated. But just so much of the parent-feed will become saccharine Salts, or Malt, as where the upper part of the plume reached in this process. The Corn, thus prepared for being dried, is, in this lively and active condition, spread on the kiln; where meeting with a heat superiour to that requisite for gradual vegetation, its farther growth is stopped; though, in all probability, from the softness of the first heat 'tis impressed with, none of the finer vessels are, by this sudden change, rent and torn, but, by drying, are shrivelled and rendered inactive, and put in a preservative state. Now, let it be observed, that those Oils

which formed the roots, being thus pushed out of the body of the grain, and dried by heat, are lost to any future wort, as they are to be screened off, seeing they are not soluble in water; which is likewise true of those parts which compose the shoot or plume: so that the internal parts of the Malt have remaining in them a greater proportion of Salts to the Oils than before, and consequently are become less viscid, more saponaceous, and more easy to be extracted.

In this process the acid parts of the grain, though they are the most ponderous, yet being very attractive of water, which occasions them to become weaker, are, by the continued heat of the kiln, volatilized,
and

and evaporate, with the aqueous steam from the Malt ; while, at the same time, the Oils become of a greater spissitude, and of a larger capacity in their pores. Thus, by Malting, the grain hath fewer acids in proportion to its Oils ; and, at the different stages of dryness, obtains different properties ; in the first stage resembling the fruits ripened by a weaker sun, and, in the last, exceeding the growth of the hottest climate.

Malt, whose colour is not altered by heat, is termed Pale Malt, from its retaining its natural whiteness ; but when the fire on the kiln is excited with more vehemence, and kept up a longer time, it affects both the Salts and the Oils of the grain, in

proportion to the degree of heat, and to the time, and thus occasions it to differ in colour : for Fire, (says Sir *Isaac Newton*) and that more subtile diffolvent, putrefaction, by dividing the particles of substances, turn them black ; an excess, which seldom is, and ought never to be the case with Malt. From the colour, with which Fire hath imprinted them, Malts receive their several denominations.

The condition the Barley was gathered in, whether green or ripe, is also clearly discernible when it is malted. If gathered green, it rather loses than gains in quantity ; for almost its whole stock of Oil being expended in germination, the Malt becomes of a smaller body, shrivelled, and

and often unkindly; while that which hath come to full maturity increases by Malting, and if properly carried thro' this process, is plump, bright, and clean, and, on being cracked, readily yields fine mealy parts, so much desired by the Brewer.

The Malts, when dried to the pitch intended by the maker, are removed from the kiln into a heap. There their heat gradually diminishes, and, from the known principles of fire, flies off, and disperses itself in the ambient Air, sooner or later, as the heap is, more or less, voluminous; perhaps too in some proportion to the weight of the Malt, and as the fire has caused it to be, more less, tenacious in its parts. Nor can it be supposed, that any of its
parts

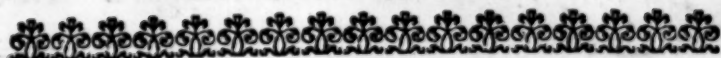
parts can so retain fire, as not to suffer it to fly off, much less keep that element in a state of inactivity, and imperceptible to our senses. Bars of iron or brass, even of a considerable size, when heated red-hot, cool and lose their fire, though their texture is, undoubtedly, much closer than that of Malt or Barley, and the experiments made by Dr. *Martin*, on bodies heating and cooling, corroborate this fact: concerning which I have been more particular than seemingly it should require, on account of the ideas that have been formed from the technical phrase used by Brewers, when they say, Malts are full of fire, or want fire; from whence a prejudice hath been conceived, by some, against drinks made from brown Malt, though they have been many months

months off the kiln, and have no more heat in them, either whole or ground, than the ambient Air they are kept in. The truth of the matter is, that in proportion as Malts are more or less dried, so are their particles separated from one another beyond their sphere of attraction, and coming in contact with another body, such as Water, strongly attract from it the uniting particles they want. The more violent this intestine motion is, the greater is the heat generated just at, and only for, that time; but the effect of this slight effervescence having been taken notice of before, it is needless to repeat what hath been said.

The minute circumstances of the process of Malting will be more readily

dily conceived from what will hereafter be said thereon. The effects that fire will have, at several determinate degrees, on what, from Barley, may be now termed *Malt*, is an object that most particularly concerns the Brewer ; and that they are various, both as to the colour and properties of the Malt, is certain ; for it appears, says *Boerhaave*, from chemical observation, that a determinate degree of heat produces, on every body, a certain effect ; and hence, as the action of it grows stronger or weaker, the effect will be different from what it was before.

SECTION



SECTION X.

Some farther Considerations on
MALTING.

BARLEYS, by Malting, may, at a medium, be said to lose one fourth part of their weight, including what is lost by the roots being screened off; though this proportion varies, according as they are, more or less, dried.

As the acrospire, and the outward and inward skins of the grain are not dissoluble in Water, the glandular or mealy substance, the only part which gives any virtue to the liquor, is certainly very small in
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quantity, and of little weight. But as this alone possesses the fermentable principles of the grain, every different circumstance heat can place it in, requires our utmost attention.

We have before seen, that Wines, Beer, and Ale, after their first Fermentation, are meliorated only by age, through the more refined and gentle emotions they undergo, which often are not perceptible to our senses. To gain this favourable effect we must form Worts, which are capable of maintaining themselves, for some time, in a sound state. This quality, if not originally in the Malt, is not to be expected in the liquor. But as some objections have been raised against this method of arguing, and these aided by prejudice, often

often more powerful than the objections themselves, it is necessary, as far as the making a proper Wort is concerned, to reassume the consideration of the Grain, as it comes from the Mow, and trace it to the Kiln, where the Fire may alter or destroy its properties.

Barley in the Mow, tho' it scarcely undergoes a heat there much greater than 100 degrees, yet may be extracted or brewed without Malting. This the Distiller's daily practice evinces; but then he commits such extracts to the Still immediately after the first Fermentation, else they would not remain long in a sound state; nor is this method practicable, even by him, in summer-time, as the very extracts would then turn
four

four before they were sufficiently cooled to ferment. By this means all the charge of the Malt-duty is saved; but our spirits are thereby made greatly inferiour to those of the *French*. *Boerhaave* recommends their method, which is, to let the Wines ferment, subside, and be drawn off fine from the lees, before they are distilled: but this can be done only with Wines from malted grain, and if practised, the difference would soon shew, how necessary and useful it is to give Wines (either from the Grape or Corn) time to be softened, before they are used for any purpose whatever.

But might not Barleys be dried without being germinated? Undoubtedly they might; but as they
abound

abound with strong Oils, they would require a more considerable heat for this purpose, by which the oleaginous parts would be rendered so compact as nearly to resemble the consistence of a Varnish, scarcely to be mollified by the hottest Water, rather than a substance fit for that element to dissolve.

Barley then, ungerminated, either in its natural state, or when dried, is not fit for the purpose of making Wines; but when only germinated, and not dried by Fire, as the coarser Oils are thereby expelled, and the mealy parts of the grain, by this act alone, become saccharine, might not this suffice without drying by Fire? Not to dwell on the difficulty of stopping germination at the proper degree without Fire, so that sufficient

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quantities of grain, thus prepared, should always be provided for the purposes of brewing; not to mention the impossibility of grinding such grain, as it would then be spongy and tough, but having regard solely to the purpose it is to be applied to, that of forming Beers and Ales capable of preserving themselves for some time; we should, on this occasion, find so many acids blended with the Water still remaining in the grain, that, in the most favourable seasons for brewing, they would render all our endeavours abortive, and in summer-time would make it impracticable to brew at all in any manner whatever.

I have heard of a project of germinating grain, and drying it in the
hottest

hottest summer's sun, in order, by this means, to malt it without the expence of fuel : but tho' the hottest days in *England* may be thought sufficient for this act, as well as for making Hay, yet as Barley and Grass are not of equal densities, the effect would not be alike. Besides, as the Grain is to be grown to a certain degree, this very hot season, so favourable, in appearance, to one part of the process, would be directly contrary to the other ; for the Barley, by this heat, would shoot, and come forward so fast, as to entangle, too much, the constituent principles of the Grain with one another, and drive the coarser ill-tasted Oils among the finer mealy parts intended to be sweet ; these alone, in their utmost purity, being the subject required for such

as would obtain good Drinks. And here I cannot help observing the general disposition of mankind, to wish for the gifts of Nature in a different manner than she has vouchsafed to bestow them. These various schemes, if I mistake not, have sprung from the desire of having Beers and Ales white or pale ; whereas they must naturally be yellow or brown : such schemes are but so many attempts to force Nature, and the prosecution of them must frequently be attended with disappointments. It is true, that tho' Malts be dried slack, yet if they be made in winter, speedily used, and brewed in the most proper season, they may make a tolerable Drink, which may preserve itself, for some time, sound : but as the proportion, which should be kept between the heat which dried
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the Malt, and that which extracts it, cannot, in this case, take place, and as the Grain will be more replete with Air, Water, and Acids, than otherwise it should be, the Drink, supposing the most fortunate success, and that it doth not soon turn acid, must still be wanting in salubrity, by frothing and exploding too much ; as an excess in any of the fermentable principles is always hurtful.

Barley then, to be made fit for the purpose of brewing, must be malted ; that is, it must be made to sprout or germinate with degrees of heat nearly equal to such as the seed should be impressed with when sown in the ground ; and then it must be dried with a heat superiour to that of vegetation, and capable of checking it.

How far germination should be carried, we have already seen ; the law here seems to be universal, as to the extent of the acrospire : the degree of dryness admits of a larger latitude, and to what extent heat may be properly carried shall be the subject of our next inquiry.

Malt dried in so low a degree as that the vegetative power is not thereby destroyed, on generating the least heat by lying together in a heap, germinates afresh, and sends forth its plumes or acrospires quite green : the ultimate parts thereof are then within each other's sphere of attraction, else this regermination could not happen ; and thus the grain may be said not to be malted, or in a preservative state. Bodies whose
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particles are removed, by heat, beyond their sphere of attraction, can no more germinate; but coming in contact with other bodies, as Malt with Water, they effervesce: and the Grain we are now speaking of, first shews this act of effervescence, when it has been thoroughly impressed with a heat of 120 degrees; and here also doth its colour, from a white, begin to incline to a yellow. Such then are Malts so cured as to be able to maintain themselves sound, yet, for this purpose, possessing as much Air, and as many acid and watery particles as they are capable of; consequently this may be termed the first and lowest degree of drying this Grain for Malt.

To discover the last degree this Grain, when germinated, is capable of enduring, we have no circumstance to direct us, with the same certainty that effervescence help'd us to the first: we must therefore have recourse to that heat which deprives it of its chiefest virtue. Now, Dr. *Shaw* says, *Alcohol is one of the most essential parts of Wine*; so that, when absent, the Wine loses its nature; and when properly used, it is a certain remedy for most diseases incident to Wines, as keeping them sound, and free from corruption: whence we have another rule for preserving vegetable and animal substances from corruption. Before this he says, *No subjects but those of the vegetable kingdom are found to produce it.* Is
Alcohol

Alcohol then a new body created by fermentation and distillation, or did it originally, tho' latently, reside in the vegetable? *I have, for a good while, been satisfied, by experiments (says Boerhaave) that all other inflammable bodies are so only as they contain Alcohol in them, or, at least, something, that, on account of its fineness, is exceedingly like it, the grosser parts thereof, that are left behind, after the separation of this subtil one, being no longer combustible.*

The use I would make of this is, that, as the same author, in his *Elements of Chemistry*, vol. I, page 195 to 199, clearly proves by experiments, N^o 8, 9, 10, 11, 12, 13, that Fire, by burning combustible bodies, as well as by distilling them, separates

separates their different inflammable principles, according to their various degrees of subtilty : hence must the Alcohol residing in the Barley, when exposed to such a degree of heat as would cause it to boil, *i. e.* 175 degrees, make great efforts to disengage itself from the Grain. From this chain of reasoning it is natural to conclude, that, in a body like Malt, prepared for fermentation, or the making a vinous liquor, this event must take place at the same time that the Malt charrs. Now, charring may well be termed the last degree of dryness, as when it takes place, the volatile parts, and those proper for forming a fermentable Must, are dissipated ; nor can any more acids subsist where the cohesion is destroyed : so that charring is a crisis in solid bodies,

dies, somewhat analogous to ebullition in moist ones ; that is, they are perfectly saturated with Fire, but their fixed principles not thereby destroyed. From hence, as liquors boil with a greater or less heat, in proportion to their tenacity or gravity, solid bodies may be said to be charred with such proportions of heat also ; so that the whole body of the Barley cannot, at the same instant, become black, nor, where any quantities are under the like situation, if not equally germinated, can the whole char with the same degree of heat. To the several reflections before made, if the following experiment be added, I hope it will prove satisfactory. And thus having two limited and distant degrees, we may thereby determine and fix the properties of the
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intermediate spaces, in proportion to their expansion.

In an earthen pan, of about two foot diameter, and three inches deep, I put as much of the palest Malts, very unequally grown, as filled it on a level to the brim. This I placed over a little charcoal lighted in a small stove, and kept continually stirring it from bottom to top: at first it did not feel so damp as it did about half an hour after.

In about an hour more it began to look of a bright Orange-colour on the outside, and appeared more swelled than before. Every one is sensible how long-continued custom alone makes us sufficient judges of colours. Then I macerated some
of

of the Grains, and found they were nearly such as are termed brown Malts. On stirring and making a heap of them towards the middle, I placed therein, at about half depth, the bulb of my Thermometer, and found it rose to 140 degrees: here the Malt felt very damp, and had but little smell.

At 165 degrees I examined it in the same manner as before, and could perceive no damp; the Malt was very brown, and, on being macerated, some few black specks appeared.

Now many corns, nearest the bottom, were become black and burnt: with all the diligence I could use, I placed my thermometer nearly there, and it rose to 175 degrees; but the
par-

particles of Fire arising from the stove, act on the Thermometer in proportion to the distance of the situation it is placed in ; for which, through the whole experiment, an abatement of 5 degrees should be allowed, as near as I could estimate ; so, a little after, putting my Thermometer in the same position, where nearly half the corns were black, it shewed 180 degrees. I now judged, that the Water was nearly all evaporated, and the heap grew black apace.

Again, in the center of the heap raised in the middle of the pan, I found the Thermometer at 180 degrees ; the Corn tasted burnt, and the whole, at top, appeared, about one half part, a full brown, the rest black ; on being macerated, still some
white

white specks appeared, which I observed to proceed from those Barley-corns which had not been thoroughly germinated, and whose parts cohering more together, the Fire, at this degree of heat, had not penetrated them; their taste was insipid, the Malts brittle, readily parting from the skin: but the Thermometer was now more various, as it was nearer to, or farther from, the bottom; and here I judged all the true Malt to be charred.

However, I continued the experiment, and at 190 degrees, still found some white specks on macerating the grain: the acrospire always appearing of a deeper black or brown than the outward skin: the Corn now fried at the bottom of the pan.

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I next increased the Fire ; the Thermometer, placed in the mean, between the bottom of the pan, and the upper edge of the Corn, shewed 210 degrees, the Malt hissed, fried, and smoaked abundantly ; tho', during the whole process, the grain had been kept stirring, yet, on examination, the whole was not equally affected by the Fire. I found a great part thereof reduced to perfect cinders, easily crumbling to dust between the fingers, some of a very black hue, without gloss, some very black, with Oil shining on the outside. Upon the whole, two third parts of the Corn was perfectly black, the rest of a deep brown, more or less so as they were hard, steely, or imperfectly germinated ; which was easily discovered by the length of the
the

the shoot. Most of them seemed to have lost their cohesion, and had a taste resembling that of high-roasted coffee.

In the last stage of charring the Malt, I set thereon a Wine-glass inverted, into which arose a pinguious, oily matter, which tasted very salt. Perhaps it may not be unnecessary to say, that the length of time this experiment took up, was four hours, and that the effect it had, both on myself, and on the person who attended me, was such as greatly resembled the case of inebriation.

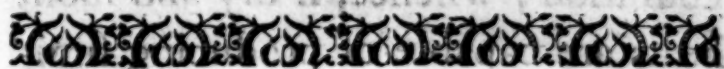
Though, from hence, it is not possible to fix the exact degree of heat in which Malts charr, yet we see some black appeared when the

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Thermometer was at 165 degrees ; that some were intirely black at 175 degrees, and at 180 degrees ; that the Grains, thus affected, were such as had been perfectly germinated, and that those which bore a greater heat were defective in that point : from whence we may conclude, with an exactness that will be sufficient for the purposes of Brewing, that true germinated Malts are charred in heats between 175 degrees, and 180 degrees ; and that as these correspond to the degrees in which pure Alcohol, or the finest spirit of the Grain itself, boils, or disengages itself therefrom, they may point out to us the reason of Barley being the fittest Grain for the purposes of Brewing.

SECTION



SECTION XI.

Of the different Properties of MALT.

THE consequences resulting from the before-mentioned experiment, will, perhaps, shew it to be one of the most useful that can be performed by the Brewer.

By the Malt charring and becoming black with the same degree of heat in which Alcohol boils, and the effect the vapours rising from them had on the persons attending the experiment, it appears, that this spirit was resident therein, and parted therefrom, when it came to the heat of

ebullition ; whence, if dry and moist heats are capable of producing similar effects as to the circumstance of preservation, then ought not this Grain, when in possession of the whole of its properties as Malt, to be made to endure such moist heats as are equal to 175 degrees, because they would deprive it of this spirit, its most preservative part : but as in fermentable Mufts this spirit is not required to appear divested of the other properties of the Grain, it should rather be intimately mixed with such as are necessary to soften, sheath, and retain it the necessary time.

Germinated Barleys, so little dried as that their particles are not removed beyond their sphere of attraction,
from

from their not being in a preservative state, cannot properly be termed Malts.

We have before seen that the first degree of dryness which constitutes them Malts, is that also which occasions them to cause some effervescence; and that this cannot be effected when they are dried with less than 120 degrees of heat, which is also the highest degree of heat that leaves them white. When urged by a Fire of 175 degrees, they begin to charr and turn black; now this difference in heat being but 55 degrees, and producing in the Grain so great an alteration as from white to black; with a little practice the different shades or colours belonging to each

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respective degree of heat, cannot easily be mistaken.

White, according to Sir *Isaac Newton*, is a composition of all colours, as Black is said to be owing to the absence of light ; and these two indicate the two extremes of the dryness of Malt. The colour with which a middling heat affects it is Brown ; and this being compounded of Yellow and Red, to speak according to accepted terms, the four colours which shade Malt differently, in proportion to its dryness, are White, Yellow, Red, and Black. The following Table, constructed on these principles, will, on macerating the Grain, readily inform the practitioner of the degree

degree to which his Malts have been dried.

A TABLE of the different Degrees of the Dryness of Malt, with the Colour occasioned by each Degree.

Deg.

- 119—White.———White.
124—W. W. Yellow.—Cream Colour.
129—W. Y.———Light Yellow.
134—W. W. Y. Y. Red.—Amber Colour.
138—W. Y. R.———High Amber.
143—W. Y. Y. R. R.—Pale Brown.
148—Y. R.———Brown.
152—Y. Y. R. R. Black.—high Brown.
157—Y. R. R. B.—Brown, inclining to Black.
162—Y. R. R. B. B.—high Brown, speckled with Black.
167—R. B.———Blackish Brown, with Black Specks.
171—R. B. B.———Colour of Burnt Coffee.
176—Black.———Black.

The several letters against each degree, it's apprehended, will the better help to fix the colour.

The above Table not only shews us how to judge of the dryness of Malt from its colour, but also, when a Grift is composed of several sorts

of Malt, what effect the whole will have when blended together by extraction : and though possibly some small errors may arise in judgments thus formed by our senses, yet as Malts occupy different volumes in proportion to their Dryness, in the practice of Brewing if the result of the Water, coming in contact with the Malt, shew the degree expected, such parcel of Malt may be said to have been judged of rightly in the Dryness it was estimated to ; so that the first trial either confirms or sets us numerically right as to our opinion thereof.

But though Malts dried to 120 degrees, are in a preservative state, yet are they the least so as Malts ; and as such possess the whole of their
Acids ;

Acids; which occasions their Fermentations and Frettings often to return of themselves, and with more violence: hence the Wines formed from such are not of long duration, but soon become sour. If the heat which extracted the Malt is kept in proportion to that which dried them, even tho' the Fermentation be very coolly carried on, and tho' the Ales or Beers be brewed in the most favourable season, they, in great measure, arrive at a state of ripeness in so small a space of time as two weeks. We may therefore consider this as the extreme for obtaining a liquor which in the least time will be fit for use.

As where Malts charr and become black, their parts are ultimately divided, so they can scarcely possess any

any Acids, nor consequently be susceptible of Fermentation: for Fermentation is a division of the parts of the body fermented, and that cannot admit of a division which is minutely divided already. The degree of heat then, prior to that which produces this effect, is the last which still retains part of the fermentable properties; and in Malts thus highly impressed by Fire, this act would proceed with so slow and reluctant a pace, that, in this case, the liquor may be said to be in the utmost state of preservation: but no time can be fixed for a duration of this sort, as if brewed with a heat similar to that which dries the Malt, it might keep many years, and thus become more subservient to the temperature of the place it was deposited in, than to its
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constituent parts. For this reason, as experience has shewn, two years are the limited space for Drinks made from Malts dried with 162 degrees of heat, before they be in their most perfect state; at which degree of heat they become first speckled with Black, and some of their finest parts begin to charr. From these two extremes, and on such principles, is the following Table formed, exhibiting the length of time that Drinks made from Malts of each respective degree of Dryness, brewed properly, and in the most favourable season, will require before such Drinks come to their due perfection of fitness to be used.

A TABLE,

A TABLE, shewing the Age Beers will require, when properly brewed from Malts of different Degrees of Dryness.

Deg.

119—White.	2 Weeks.
124—W. W. Yellow.	1 Month.
129—W. Y.	3 Months.
134—W. W. Y. Y. Red.	4 Months.
138—W. Y. R.	6 Months.
143—W. Y. Y. R. R.	6 Months.
148—Y. R.	10 Months.
152—Y. Y. R. R. Black.	15 Months.
157—Y. R. R. B.	20 Months.
162—Y. R. R. B. B.	2 Years.
167—R. B.	
171—R. B. B.	
176—Black.	

It must be observed, that the foregoing Table is constructed only on the properties of Malt supposed to be brewed and fermented with the utmost care, with the intervention of Hops; an ingredient which shall be considered in its proper place. What is meant by the *Extracts being*

ing in proportion to the Dryness of Malt, may merit some farther explanation.

Grapes, when ripe, carry with them the Water they have received, both during their state of growing, and that of their maturity, which is sufficient to form their Musts with. To dried Grapes, or Raisins, Water is applied, because they are deficient in this property; as, for the same reason, it is requisite in regard to Malt: but as Grapes stood in no need of artificial Fire to ripen their principles, so what they produced themselves, and cold Water, or what is nearly so, added to dried Raisins, is a sufficient menstruum to extract them. But Barleys requiring the assistance of a great heat to bring their
parts

parts to such proportions as will give them a preservative quality, require also a similar heat in the Water to help to digest them : but here they are considered as not assisted by the effect of Hops, which, when they take place, yielding abundance both of Salts and Oils, require other proportions in the Extracts, and such as create a likeness to the Dryness of the Malt, and a regard to be had to the effects of the Hops also.

But we often see liquors brewed from very pale Malts, preserve themselves for a long time ; and we also see brown Malts so managed as to disappoint us as to the time their liquor should preserve itself sound. The first of these cases is when the Extracts are made with very hot Water,

ter, as the latter is when the Water is too cold for this purpose: for as heat, either moist or dry, bestows the preservative quality, 'tis the medium of the dryness of the Malt, and of the heat of the Extracts, that, in this case, the Table indicates, by means whereof it shews the space of time the liquor may be expected to keep, before it be full ripe.

Well-brewed Drinks should not only preserve themselves sound their due space, in order to be meliorated by time, but, as the most certain sign of the Artist's skill and care, as well as of the salubrity of the Drink, they should be fine and transparent; this sign comprehending the whole of a well-formed Must, and of a perfect Fermentation. If then the rules for
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obtaining these ends can be deduced from the foregoing principles, and the last-recited experiment, and these be strengthened by the ideas of men who best understand Nature and her laws; we may then flatter ourselves with possessing a Theory which will answer our expectations in practice.

Between the parts of opake coloured bodies (says Sir *Isaac Newton*) are many spaces replenished with mediums of other densities; as Water between the tinging corpuscles wherewith any liquor is impregnated; and the discontinuity of parts is the principal cause of the opacity of bodies. Salts undissolved, and without a medium, form an opake body, as also Oils not perfectly incorporated with Water; from whence we may con-

conclude, that all Mufts which are not faponaceoufly formed, or whose conftituent parts are not diffolved into one homogeneous body, are not fit either for a perfect Fermentation, or to produce a pellucid liquor; and faponaceous bubbles, fays the fame Author, will, for a while, appear tinged with a variety of colours, which are agitated by the external Air; and thofe bubbles continue until fuch time as, growing exceffive thin by the Water trickling down their fides, and being no longer able to contain the inclofed Air, they burft. As they thus vary their denfities in proportion to their duration, the colours they reflect muft alfo continually vary: and hence arifes the impoffibility of judging of the condition or faponaceousnefs of Ex-

tracts of Malt from the appearance of their froth. This, indeed, has, for a long time, none other being known, been accounted the best method: but in deference to the opinion of so great a man, it should, at present, give way to the use of the Thermometer, which is the only instrument by means whereof we can obtain clear and fine Beers, as it enables us numerically to fix the heat of the liquors we extract with.

When Extracts are made without the proper degree of heat, that is, when either the Malts are not sufficiently dried, or the Water is not powerful enough in heat, the Oils of the Malt do not mix perfectly with the Water, and the liquor is deficient in transparency.

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On the other hand, Extracts made with Waters so hot that the constituent parts are thereby removed beyond their sphere of attraction, or the Oils coagulated so as to form a body separate from the Water, must needs be opaque. Worts or Musts can never, in either of these cases, yield a transparent Wine; whereas with a due heat, which should be the medium of these two, they must be perfectly so; and as they remove from such medium, they will be more or less valuable.

Length of time, which improves Beers and Wines, often rectifies our errors in this respect; for the Oils being, by various frettings, more attenuated, and more intimately mixed, the liquor is, by this means, of-

ten restored, or rendered homogeneous ; yet I never found this to succeed, where the error on the whole of the dryness of the Malt, and the heat of the Extracts exceeded the medium, for this purpose, by 14 degrees.

Art also has, in some measure, remedied this defect. For when Beers or Wines are suffered to stand till they are rather in an attracting state, than in a repelling one, that is, till their Fermentations and Frettings have had their course ; then, if they do not fall spontaneously fine, they may be precipitated, by mixing therein a fluid body more ponderous than the liquor : all the floating particles, that occasioned its foulness, are, by this means, made to subside
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to the bottom, and leave a limpid Wine: but the power of dissolved Isinglass, the ingredient generally used for this purpose, seldom takes effect above a medium, as before, of 14 degrees.

Indeed, other ingredients have been used, which carry this power near 10 degrees farther. Whether such things be salutary, is not my province to determine: it would undoubtedly be better if there were no occasion for them: but beyond the limit precipitation hath no effect; as the liquor which cannot be fined thereby, if attempted by increasing the quantity of the precipitants, must be injur'd in the taste, which will be over-power'd by the menstruum. How frequent this last case of *cloudiness* is, would answer

no purpose, in this place, to enquire. The use of doubtful ingredients, and such errors as have been mentioned, need no longer blemish the art, when a constant and happy practice will be both the effect and proof of a solid and experimental Theory.

Beers which become bright of themselves, or by time alone, as well as those precipitated with dissolved Isinglass, and others with more powerful ingredients, each possess their peculiar properties in a certain latitude, or number of degrees; and as these effects arise wholly from the heats employed in drying the Malts and in forming the Extracts, the following Table will be of use to point them out.

A TABLE,

A TABLE, shewing the tendency Beers have to become fine, when properly brewed from Malts of different Degrees of Dryness.

119—White.	Latitude of pale Malts, which, when properly brewed, become spontaneously fine, even so far as 138; when brewed for Amber, by repeated Fermentations, they become pellucid.
124—Cream Colour.	
129—Light Yellow.	
134—Amber Colour.	
138—High Amber.	By Precipitation these grow bright in a short time.
143—Pale Brown.	
148—Brown.	With Precipitation require 8 or 10 Months to be bright.
152—High Brown.	
157—Brown, inclining to Black.	With Precipitation these may be fined, but will never become bright.
162—Brown, speckled with Black.	
167—Blackish Br. speckled Black.	These, with difficulty, can be brewed without setting the goods, and will, by no means, become bright, not even with the strongest acid Menstruum.
171—Colour of burnt Coffee.	
176—Black.	

Thus doth the success of this Art depend on the instrument so often mentioned : which, by pointing out the difference of expansion caused by different heats, becomes a sure guide. I shall now close this account of Malts, as I did that of Fermentations, by comparing with these principles the defects which we but too often meet with in Barley when malted.

SECTION



SECTION XII.

Observations on Defective MALTS.

IN the preceding enquiry some of the Defects of Malts have been occasionally mentioned: but as a perfect knowledge of the Grain, especially when it hath undergone this process, is a matter of no small concern to the Brewer, I shall now bring such defects into distinct view, both to compare them with the foregoing principles, and that they may be more at hand, on every occasion, when wanted.

Every different degree of heat acting on bodies causes a different effect; and
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this varies also, as such heat is more or less hastily applied. The proper act of germination is when the moisture given to the Grain is not excited by too much warmth; for in the same proportion as the warmth is, the vessels must be distended; and if the motion is violent, they more greedily imbibe the coarser Oils, and in greater quantity: by this means the glandular parts of the vegetable are filled with sulphurs less delicate, and of greater spissitude; and these being to form the saccharine salts, with the greater briskness this act is carried on, the less sweet, and the coarser will these salts be when dry, even often tending to a bitter. For these reasons, if I may be permitted the distinction, I apprehend there is a material
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one between Germination and Vegetation. The former seems to be the act caused by heat and moisture, while the plume or acrospire is still enveloped within the teguments of the parent Grain, which is most perfectly performed by the gentlest action, and the least heat that is capable of moving the different principles of the Grain in their due order. Vegetation again is that act when the plant issues forth, and, being rendered stronger by the impressions of the Air, becomes capable of resisting its inclemencies, or the warmth of sun-shine. Germination is the only act necessary for malting, the intention being solely to put in motion the properties and principles of the parent Corn, and not to push up the embryo to a plant: now, as this begins

begins in Barley at the degree where Water begins to be fluid, or nearly so, the cold season, when the Thermometer shews from about 32 to 40 degrees, is most proper for this purpose, and to render the salts truly saccharine. How far its latitude may, with propriety, be extended, experience alone must determine. Maltsters continue to work as long as they find the Season proper, and leave off generally in *May*, when the heat of the Water is, at a medium, from 50 to 55 degrees. But the nearer they come to this medium, with the greater disadvantage must they malt: so that we may conclude it to be an original defect in Malt, if it be not germinated in the cold season, as otherwise its saccharine
parts

parts must be impressed with a disagreeable taste.

Malt which hath not had a sufficient time to shoot, so that its plume may have reached to the extent of the inward skin of the Barley, will have remaining therein too large a quantity of Earth and Oils, which would otherwise have been expended in the acrospire and radical vessels; and all those parts of the Corn which have not been separated, and put in motion by the act of Germination, will, when laid on the kiln to dry, harden and glutinize; so that no greater part thereof will be soluble in Water, than so far as the stem or spire of the Barley rises to, or very little farther, and as much as is wanting thereof, will be just so much loss to the Brewer.

When

When Malts are suffered to grow too much, or till the spire shoot thro' the skin of the Barley (which is not often the case) tho' all that is left be Malt, that is, contains Salts dissoluble in Water; yet as too large a portion of Oils hath been extracted out of the Grain, such Malts cannot be fit to brew Drinks for long keeping; besides the loss of the substance of the Corn occasioned by its being overgrown.

Malts which have been but just enough grown, and have been duly worked on the floors, if not thoroughly dried on the kiln, even tho' the Fire be excited to a proper heat, must retain many watery parts, which will cause the Corn, when laid together, to germinate afresh; perhaps
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to heat and take fire : should it continue long in this state, it must, at least grow mouldy, and have an ill flavour.

Malts well grown, and worked as before, but over dried, though with a proper degree of heat, will become of so tenacious a nature, as to require a long time before they can admit the outward impressions of the Air to relax or mellow them, that is, before they be fit to be brewed with all the advantages they otherwise would have.

Malt dried on a kiln not sufficiently heated must require a proportionably longer time to receive the proper effect of the Fire ; which if it have not, it will be in the same case

case as Malt not thoroughly dried, as above.

If too quick or fierce a Fire be employed to dry Malt, instead of gently evaporating the watery parts of the Corn, it torrifies the outward skin thereof, so rarefies the inclosed Air as to burst the vessels of the Grain, and divides the outward skin from the body of the Corn, (such are called *Blown Malts*) by which means it occupies a larger space. If such a Fire be continued, it even vitrifies some parts of the Grain, from whence the Malt is said to be *Glassy*. Malts, which from their being thus hardened, are rendered of a steely nature, will not dissolve, or but in a small proportion, and are very troublesome and dangerous in brewing,
as

as they frequently occasion a total want of extraction, which is termed, *Setting the Grist.*

Malts just, or but lately taken off the kiln, generally remain warm for a considerable time. But till they become equally cool with the surrounding Air, they cannot be said to be mellow, or in a fit state to be brew'd; for as their parts will be harsh and brittle, the whole of their substance cannot be resolved, and the proper heat of the Water, which should be applied to them for that purpose, is therefore more difficult to be ascertained. The practice of those Maltsters, who sprinkle Water on Malts newly removed from the kiln, to make them appear as having been

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made

made a considerable time, or, as they term it, to *plump* them, is a deceit which merits attention ; for by this practice the circumstance of the heat, and harshness of the Malt, is only externally and in appearance removed, and the purchaser grossly imposed on ; as by being thus treated it occupies a greater volume, and, if not speedily used, soon grows mouldy, heats, and is greatly damaged.

The direct contrary is the case of high-dried Malts, which have been made a long time : the dampness of the Air hath relaxed them, and so much moisture hath insinuated itself into the Grain, that it cannot readily be ascertained how much hotter the Mash should, for this reason,
be.

be. But supposing no distemper, such as being mouldy, heated, or damaged by vermin, Malts in this case may more certainly be helped in brewing, than those just above-mentioned. It appears, therefore, how necessary it is to procure Malts which have been wetted and germinated to their true pitch, dried by a moderate heat, raised to its true degree, so as the moisture of the Corn may be duly evaporated, then cured so as to preserve themselves a due time, without being blown, vitrified, or burnt by too hot or hasty Fires. How easy it is to regulate this process in the cistern, on the floors, and on the kiln, when the Maltster uses no artifice to save his excise, I need not explain. But with what certainty and skill the whole might be

carried on by the help of the Thermometer, I leave such to say, who are modest enough to think, that the Art may be brought to more accurate rules than those of the determination of our unassisted senses. As such rules may easily enough be deduced from what hath been said, I shall not be particular in laying them down here; that not being my immediate purpose, nor my business as a Brewer; and especially as I have neither leisure, nor the convenience of a Malt-house, to make experiments of this sort; yet I may, with great truth, say, that such as would not be disappointed in their brewing, must take care not to be deceived in their Malt. This, however, being but too frequently the case, it is undoubtedly best to treat
faulty

faulty Malts by the same rules as if they were perfect ; by which means the well-malted parts alone will be digested. If they be too slack dried, they may be corrected by an addition of heat ; and if over dried, or injured by Fire, they may be proportionally helped in the extracts ; of which the Brewer will be best enabled to judge from his first liquor, by applying the Thermometer thereto, and this to a sufficient degree of exactness.

I flatter myself some satisfaction must arise from seeing both what is perfect, and what is defective in the principal processes of this Art agree so well with its Theory, as these are so many proofs of its certainty ; and though there be several incidents (as
yet

yet unmentioned) inseparable from the practice thereof, these will only serve to confirm this truth, that when our task is to imitate *Nature*, it is our duty, by study, to inform ourselves of, and industriously to practise, her laws.



F I N I S.